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QUEENSLAND

NOTE ON AGRICULTURAL CONDITIONS AND COTTON-GROWING PROBLEMS

BY

W. G. WELLS.

Inherent Agricultural Circumstances.

The section of Queensland in which cotton has been most extensively grown extends from the foothills of the mountains on the southern border northward to the Tropic of Capricorn, and mostly lies in between the Coastal Range and the Main Dividing Range. This area is approximately 400 miles in length and varies in width from 70 miles to 150 miles. Connecting ranges divide this tract of country into three large watersheds each of which has one fair-sized river and several contributing creeks of varying capacities and length. Most of the country is thus very undulating with the alluviums of the main and subsidiary streams varying from one-quarter of a mile to three miles wide and fronting long slopes of slight to steep grade in most of the large valleys.

Cotton has also been grown to a varying extent to the west of this area along the southern slopes and in the valleys of the foothills of the Main Range, and in scattered places in the northern part of the State, particuarly in the Burdekin River Delta.

The soils of the cotton-growing districts vary considerably, much of the slopes being of basaltic origin adjacent to what appears to be mostly the Black and Brown earths, while on some watersheds considerable areas of sandstone and also limestone origin occur. The alluviums are therefore composed of a wide range of soil types, but are mostly characterised by strips of sandy loams of varying depth and width adjacent to the streams, and increasingly heavier loams and clays extending from the sandy loams towards the foothills.

The general fertility of the soils in the virgin state is high except in the sandstone areas. Much of the country on the slopes is rather steep for cultural operations and soil erosion occurs where improper cropping practices are followed. The productivity of much of the older cultivated slopes has therefore deteriorated and in some districts soil conservation measures are urgently required.

The mean annual rainfall for most of the sections of the main area varies from 28 to 30 inches, but is greater in the sections adjacent to the Coastal Range. The rainfall is not reliable, but approximately 25 per cent. of the year's total usually occurs during August, September and October, 50 per cent. during November, December, January and February, and the remainder in the rest of the year. October is usually the wettest month of the first period, January or February of the second period, and March of the third period, although June is a fairly reliable month for soaking rains.

The mean annual rainfall is ample for the range of crops grown in this area, but both the irregular distribution and the intensity of rainfall may seriously affect the usefulness of the year's total precipitation. During the wet period upwards of 50 per cent. of each monthly total may occur at the rate of 0·7 of an inch or greater per hour, while as much as 40% of the annual rainfall may be of this intensity.

The temperatures in the main cotton districts are well-suited for growing this crop—the frost-free period being from early October to June in most seasons, although a light frost is occasionally experienced by mid-May. The monthly mean maximum screen temperatures during the growing period vary from approximately 85°F. for October, through a steady rise to 93°F. in January, and then a slow decline to 75°F. in May, with slightly lower means for the higher sections of the southern part of this area. The mean monthly minima range around 55°F. for October with a fairly constant rise to 68°F. in January, and then a steady decline to 45°F. in May. The winters are pleasant during the day but chilly at nights—the means ranging around a maximum of 70°F. and a minimum of 40°F. in June, July and August. Cold westerly winds cause sudden severe drops of the minimum temperatures, however, during July and August, when upwards of fifteen frosts per month may be experienced with temperatures occasionally as low as 20°F.

The Agricultural System.

The system of agriculture practised in the main cotton-growing areas depends primarily on the age of settlement of the district, the soil type, topography and size of the farm, the distance from markets and the climatic conditions. In the more southern part, much of which was settled between 1860 and 1900, the farm area ranges mostly from 100 to 200 acres. Many of these farms consist of fertile alluvial flats and slopes of either very fertile scrub or reasonably productive forest soils, although soil erosion has reduced the productivity of the older cultivations on the slopes. As the districts concerned are adjacent to Brisbane, the largest market in the State, a wide range of crops has been grown. As the markets for butter and pigs expanded, dairying increased and is now the largest industry in this area. In more recent years, lucerne and vegetable crops have been grown extensively on the fertile alluvial soils with the assistance of supplementary irrigation water obtained from wells and creeks. This form of agriculture will undoubtedly increase in the post-war period in this and other districts, as it is the declared policy of the State Government to foster such practices wherever economically possible.

Cotton-growing was the means of settling much of the southern part of this district originally, and following the 1914–18 war, high prices stimulated interest again in this crop. The annual total area of cotton in it has not exceeded 12,000 acres, compared to the State annual mean of roughly 54,000 acres, however, owing to the individual

areas being limited to what the regular farm labour can harvest. Cotton has also mostly been confined to the lower, less fertile slopes and secondary benches of the narrow valleys, owing to the danger of rank growth developing on the fertile alluvials during a wet period if the bottom or middle crop has been lost. The providing of ample subsoil moisture to carry the crop through stress periods is essential for the production of good yields in most seasons. Unfortunately most of the farmers in the southern districts have inherited or acquired an "annual crop" complex and the grassland-cotton rotation is seldom adopted. Many hillside cultivations should be re-designed to permit the application of suitable soil conservation methods among which would be the establishment of grassland to restore the permeability of the soil, and a crop rotation with cotton followed by a legume as the pre-treatment needed to maintain the soils in a suitable condition for the satisfactory production of pastures.

In other sections of the main cotton-growing area somewhat similar conditions and practices prevail. Many of these districts have been settled since 1920, however, and in addition, being at considerable distances from Brisbane, the Crown has designed them on the basis that dairying and pig raising would be the main industries, with major cash crops such as cotton to supplement the farm income. The size of farm has therefore ranged from 200 to 400 acres where the soils are fertile and most of the farm is suitable for cultivation, to considerably larger areas to allow of small-scale cattle fattening where the country is ridgy, open forest foothills and better suited to pastoral activities.

Cotton-growing has played a very important part in the development of these newer opened areas. The slopes were often densely covered with thick scrub. By felling the scrub and burning it, cotton could be grown in the ashes of the burn without incurring cultivation costs—few, if any, weeds developed after the burning operations. At the end of the wet season, seed of Rhodes grass (*Chloris gayana*) was sown amongst the cotton to establish a pasture in the following season. Although the yields of cotton might be light, the relatively low costs of production usually ensured payable returns. In this manner several hundred thousand acres have been grassed. The forest country was mostly of a more open type than the scrub areas and consequently was brought into cultivation in the first year of clearing. The clearing was expensive, however, and without a remunerative crop like cotton, the development of much of the forest country would have been greatly retarded.

Cotton has thus largely functioned as a developmental crop until the farms were sufficiently grassed and improved to carry sizeable dairy herds. The returns from dairying and the accompanying pig-raising have been so attractive on these highly productive pastures that there has been a tendency for the farmers on the larger areas to reduce their cotton area or cease growing it altogether. Any remaining undeveloped country on their farms has been made available to share farmers for two or three years as payment for clearing of the land,

following on which the farmer grassed the area. In some districts the share farmers of late years have accounted for the greater part of the cotton produced.

Ample evidence is now obtainable on all old pastures, however, that pasture renovation is going to be urgently required in the near future on many farms. Cotton is outstandingly the most suitable crop to use in such renovating practices, for reasons that have been described in many of the Annual Reports of the Biloela Research Station. Cotton-growing has thus played an important part in the pioneering of this big area ; it should have an even more important place in its future agricultural development.

Normally ample labour would be available for increased cotton production, but under the present shortage of labour throughout the country and the demand for the production of foodstuffs, no worth-while improvement to the cotton position appears possible now, particularly as the industry requires a great deal of hand labour. In the post-war period cotton-growing should occupy a very important place in the crop rotations practised on many farms.

Agricultural Practices.

Much of the cotton produced in the past has been grown under pioneering conditions which prohibited the use of efficient cultural practices. In more recent years there has been an increasing tendency, except in the older settled southern districts, for many growers to adopt the grassland-cotton rotation and to use modern tractor equipment in the cultural operations. Earlier ploughing of both the grassland and the cotton land should be a general practice, however, in order to conserve the subsoil moisture resulting from the late summer and autumn rains. Such subsoil moisture increases the possibilities of obtaining and satisfactorily maintaining an early planting of rain-grown cotton. Investigations and commercial plantings have conclusively demonstrated in most cotton-growing districts that crops planted by the end of October will normally out-yield later plantings. Planting should be completed, however, by mid-October if possible. Irrigation facilities ensure both planting at the right time and offsetting stress conditions during mid-season and should, therefore, be installed wherever economically possible.

More attention should also be given to reducing cultivation costs, which can be effected on non-irrigated areas not only by the use of the grassland rotation but by cross-harrowing in the early stages of seedling growth and using suitably equipped cultivators to control weeds later in the season.

Row and plant spacing is reasonably satisfactory as a whole although some of the larger growers, in an endeavour to reduce thinning costs, tend to plant at a somewhat light rate and consequently do not obtain a uniform stand of the recommended plant spacing of 12 to 24 inches, according to the soil type.

The average yield per acre of the area planted is relatively low —approximately 300 lb. seed cotton per acre. However, by using efficient cultural methods, yields up to 1,200 lb. seed cotton per acre are frequently obtained. In good seasons, a considerable number of 1,500 lb. average yields on areas of 40 or more acres have been realized, while smaller areas have yielded up to 2,100 lb. per acre. These good yields indicate that a greater use of the grassland-cotton rotation in conjunction with earlier ploughing is required before good yields of rain-grown cotton can be reliably expected. The application of supplementary irrigation also improves yields—at the Biloela Research Station a mean yield of 1,514 lb. seed cotton per acre has been obtained over the last four years in experiments to test the merits of supplementary irrigation. In other experiments, and also in demonstrations on farms, yields up to 1,900 lb. seed cotton per acre have been realized.

Economic Attractiveness of Cotton.

Owing to the cost of labour for harvesting cotton in this country, it is unlikely that the industry will develop on any substantial scale in Australia without financial assistance provided by either bounty payments or a protective tariff. The amount of assistance required will depend on the returns from the other agricultural industries that can be engaged in on the land where cotton can be grown, and the average yield of cotton obtained. In most districts the majority of growers have required considerable assistance to make their returns at all comparable with those realized in dairying and pig-raising activities.

Where appropriate cultural practices are used under both rainfall and irrigation conditions, good yields of cotton can be produced in most seasons. Owing to the importance of developing cotton-growing on an extensive scale in this country under both rainfall and supplementary irrigation in the post-war period, financial assistance should be continued, however, to make cotton a sufficiently attractive crop to engage the attention of the best equipped farmers in the cotton-growing districts of this State.

Cotton Varieties.

Since 1924 a wide range of American Upland short and long staple varieties of cotton have been tested in the main cotton-growing districts of Queensland. The results obtained have indicated that owing to the range of soil types suitable for cotton in any of these districts, it is extremely doubtful if any variety will be discovered which will be entirely satisfactory for all soil types of any one district or that the varieties suitable for one district will be suitable for all districts. There appears to be a distinct variety-soil association operating to some degree in each district which necessitates that varieties of the following types should be available :—(i) quick-fruiting with an open habit of growth, suitable for very fertile alluvial soils in

the better rainfall areas; (ii) medium quick fruiting with a fairly open habit of growth for the less fertile clay loams in the better rainfall areas and the fertile loams and clay loams in the average to lighter rainfall areas; and (iii) medium slow fruiting with an open type of growth, but having marked drought resistance for the less fertile soils in the lighter rainfall areas.

The range of possible varieties has been narrowed to Triumph and Farm Relief for the first type; Miller and New Mexico Acala for the second type; and Lone Star for the third type. Rowden for the second type and Qualla for the third type are also being investigated to some extent. Much work may be required to develop thoroughly satisfactory strains of either Triumph or Farm Relief although several good-yielding types of the former are now available which produce full $\frac{15}{16}$ inch cotton with 35% lint. Better boll size and stronger fibre of 1 inch length are the main requisities in Triumph, while a less vigorous growing type with stronger and more uniform fibre of $1\frac{1}{16}$ inches in length is needed in Farm Relief.

The main objectives in the improvement work in Miller are a more open habit of growth, slightly quicker fruiting and a higher lint percentage than the present 34–35% of 1 inch hard-bodied cotton. The New Mexico Acala is satisfactory in most respects excepting strength and length of fibre. This variety appears to have definite possibilities for growth with supplementary irrigation in the drier districts, but stronger $1\frac{1}{16}$ inch fibre is needed to make it entirely suitable. The Lone Star variety is generally satisfactory in plant type, but slightly stronger fibre is required than the present 1 inch cotton with 36 lint percentage, to ensure of satisfactory quality being produced in very dry seasons. Work in Qualla aims at maintaining its very satisfactory standard of 1 inch cotton of 38 per cent. lint, but evolving a slightly quicker fruiting type. Rowden has shown promise of being more suitable than Miller for fertile soils in the medium rainfall areas where Triumph and Farm Relief yield well but produce rather inferior cotton if a mid-seasonal "dry-up" is experienced. Rowden is rather variable in type and therefore may be a fruitful field in which to search for a medium-early hard-bodied cotton with a very open type of growth that may possibly be suitable for machine harvesting—preliminary harvesting trials of it having yielded promising results at the Research Station.

In addition to the factors relating to the varietal-soil association affecting yields, jassid attacks may seriously reduce crop production on certain soil types in some seasons, particularly in late-planted cotton. Accordingly, the development of jassid-resistant strains has been undertaken by the usual selection methods within the older stocks of Miller in which apparently jassid-resistant plants have been occasionally noticed. In conjunction with this line of attack, the development of resistant types by hybridizing Miller strains with U.4 has also been attempted. Both methods have yielded very promising results and it would appear that where a jassid-resistant Miller type of cotton is

required, the demand can be met. Accordingly the development of resistant strains of the very susceptible varieties Triumph, New Mexico Acala and Lone Star, has also been started in a programme of hybridization with the resistant Ferguson and Rhodesian strains, as all three varieties are grown in districts where crop loss by jassid attacks may occasionally be very severe.

Insect Pests.

Several insects attack the cotton crop. Some are of major importance and reduce yields each year; others are occasional or minor pests which can scarcely be considered a limiting factor to production, though they may, at times, cause a great deal of damage to individual crops in some districts. The problem pests, *i.e.*, the pests which can adversely influence the future of the industry are corn ear worm, jassid, pink bollworm and rough bollworm.

Each year the larvæ in three generations of the corn ear worm, *Heliothis armigera* Hbn., are liable to attack cotton during the three-month period between December and February, when the fruiting forms which yield the commercial crop are on the plants. Normally only one of these generations assumes serious proportions and, if the outbreak takes place when the plants are young and squaring freely, the damage is considerable. Egg counts on a selected number of terminals at weekly intervals permit the detection of peaks of egg-laying with considerable accuracy in any one ecological unit such as the Callide Valley. Insecticides can only be expected to control the pest if they are applied during and shortly after each burst of egg-laying. It still remains to be proved, however, that lead arsenate sprays or dusts, even when properly timed, can give economic control. Cultural practices such as early planting on well prepared newer cultivations favour the setting of an early crop and the development of plant characters which tend to minimise losses. The vagaries of the weather and the unpredictable behaviour of the insect, however, make all such methods of evading attacks somewhat unreliable, particularly as they presuppose a high standard of farming practice.

The cotton jassid, *Empoasca maculata* Ev., has become particularly important during recent years, especially in scrub areas characterised by red volcanic soils. Populations rarely become high until the end of January and the insect is therefore primarily a pest of late-planted crops which set and mature their bolls from February onwards. Early-planted crops which, because of dry weather or attacks by corn ear worm, lose their first-formed squares, also mature a late crop and may suffer in much the same way. Direct control measures cannot be economically applied and the entomologist is therefore interested chiefly in determining the causes of the sharp fluctuations in populations which occur during the season and in elaborating the morphological basis of the plant's resistance to the pest. Such information should be of value to the plant breeder whose task it is to develop resistant varieties and resistant strains within existing varieties.

In Queensland the pink bollworm, *Platyedra scutigera* Hd., differs from the practically cosmopolitan species in both its structure and habits. It is primarily a pest in late-maturing bolls and therefore causes more loss in late- than in early-planted crops. As scrub areas in which its native hosts occur are eliminated, and the acreage under ratoon and standover cotton declines, the importance of this insect is becoming less. Ginnery operations appear to destroy larvæ received in the seed cotton and it is questionable if machine delinted seed requires any special treatment before its distribution to the grower.

The rough bollworm, *Earias huegeli* Roz., causes variable losses from year to year. No satisfactory control measures are available. In spring and early summer, terminal damage often causes vegetative growth but, later in the season, injury to squares and bolls is more important. Alternative malvaceous hosts are common in the main producing areas.

Minor pests include cutworms, false wireworms, flea beetles, leaf perforator, looper and the spur-throated locust.

Seed Supply, Ginning and Marketing.

The development of suitable varieties of cotton and the maintenance of ample supplies of seed of them is the responsibility of the Queensland Department of Agriculture and Stock, through legislation passed with the approval of the cotton growers, at the termination of the period of Government guaranteed prices in 1926. The operations of ginning, delinting and heat sterilizing the planting seed are carried out under Government supervision by the Queensland Cotton Board, a Co-operative Commodity Organization, which takes possession of all cotton produced in Queensland, when loaded at the grower's nearest railway station, and pays all transportation, grading, ginning and marketing expenses. The total net proceeds are pooled and returned to the growers annually on a per lb. of raw cotton basis which includes premiums for grade and staple.

Use of Cotton Seed.

The cotton seed is milled by the Queensland Cotton Board as part of the general operations of processing the cotton crop. The linters are used for various purposes customary for this product, the hulls are fed to dairy herds in the vicinity of the oil mill, while the meal is in great demand for the dairy herds in the coastal areas where pastures are deficient in protein during the dry periods of the year. The oil finds a ready market for the manufacture of cooking margarine, for processing dried raisins and in bakeries and pastry making shops.

A GENERAL REVIEW OF THE COTTON-BREEDING WORK

BY

W. G. WELLS.

The following account of the breeding programme as it has been developed over the years, and a description of the objectives which it seeks to attain, are supplied at the request of the Corporation :—

Broadly speaking we have found that there is such a close association between soil and varietal types as well as climate that we have to carry out the regular cotton breeding work at several centres, except where jassid-resistance is absolutely necessary in a variety. Accordingly, the improvement work on Triumph cotton under rain-grown conditions is done in the Southern district on a moderately fertile soil which is typical of the lower slopes of the valleys of that area. These soils require fairly quick-fruiting types, yet the mid-seasonal dry-up necessitates that they should also have a substantial degree of drought resistance. Work is also done on the Triumph variety in the Central Burnett district where the alluvial soils are of a fairly forcing type but the mid-seasonal climate makes it advisable to grow a quick-fruiting type like Triumph under irrigation facilities. The Burnett River is one of the largest of the possible irrigation future developments in our main farming areas, hence we feel justified in carrying out a fair amount of breeding work in this variety under irrigation facilities, particularly as the Upper Burnett on the head waters of the Burnett River will also probably have a fair amount of irrigation development on fertile soils. Similarly, the work done there should be of value to the South Burnett where the Barambah Creek, which is a branch of the Burnett, will undoubtedly provide considerable irrigation facilities for fertile country.

No improvement work on Triumph has been done at the Biloela Research Station because the January temperatures are entirely too harsh for it and consequently, although the yields may show improvement over Miller, the fibres are definitely inferior to the harder-bodied Miller. Also the harsh conditions may restrict boll development in Triumph, which has only a medium boll, to a much greater extent than in the considerably larger-bolled Miller.

Breeding work in the Lone Star variety is concentrated under rain-grown conditions on some of the forest soils of the western portion of the Central Burnett. These soils are fairly typical of a fairly large area of the districts receiving less than 28 inches annual rainfall where Lone Star has been demonstrated over a series of years to be the most promising variety. We have made very satisfactory progress in improvement of plant type, increasing the strength of fibre and the lint percentage, as well as making the variety more suitable for the stress conditions which frequently are experienced in the less than 28-inch rainfall belt. The variety grows too rankly on fertile alluvial soils, and it is nearly always the lowest yielder when it has been tried in varietal trials at the Biloela Research Station. We have not,

therefore, done any breeding work on it at that centre, particularly as Miller has outstandingly surpassed it in yields in any district trials carried out in the Callide Valley.

The breeding work in the Miller variety is concentrated in the Callide Valley where the bulk of this cotton is grown. However, the stocks originating from the work there have been found to be entirely suitable for " safe " Miller soils in other districts. We feel, therefore, that the Callide Valley Miller work takes care of the Miller country in all portions of the State.

The only other variety receiving much attention is the New Mexico Acala, which has a slightly longer staple than Miller, with a higher lint percentage and an open type of structure which makes it suitable for growing under irrigation facilities on the medium fertile alluvials in the Central District. Improvement work in this variety is done on a co-operator's farm near the Research Station, under irrigation. Unfortunately this variety tends to react to harsh mid-seasonal climate under rain-grown conditions more than does Miller, and it will eventually probably be replaced in the Central District by the latter, except where irrigation facilities are available. As we want to grow as much $1\frac{1}{16}$ inch cotton as we can, we also do work on New Mexico Acala in the South Burnett, where under rainfall it yields well on the less forcing soils of the lower forest slopes.

The Biloela Research Station was originally developed as a joint investigational area and pure seed centre for evolving suitable types of the old Durango variety and learning how to grow them. As a better understanding of the various problems in the different districts was obtained, we gradually changed the Research Station into a centre for agronomic investigations and the study of the reactions of the various main Queensland varieties and newly introduced varieties to both soil and climatic conditions. This appeared to be desirable as there were no other experiment stations in the main cotton-growing districts, and it was obvious that we could get a better insight into the problems and the respective merits of varieties than could be done solely on co-operators' farms with the help of extension officers. Accordingly the breeding work in the Miller variety has been done with co-operators in the Callide Valley in order to get the necessary isolation for the progeny areas and the multiplication plots, but all strain trials of the Miller selections have been brought to the Research Station in order that we could do more intensive testing of their merits and thus get a better understanding of the reaction of the strains to the various major alluvial soil types in the Valley that are represented on the Station.

When the jassid problem became more pronounced in the different districts it was decided to station a Research Officer, Mr. Marriott, at Biloela, where considerable facilities could be provided for him to carry out a comprehensive hybridization programme aiming at evolving a jassid-resistant type out of U.4 and Miller crosses. It was

felt, however, that straight line selection of apparently jassid-resistant types should be done in fields of commercial Miller grown in the sections of the Callide Valley where jassids were usually an important factor. In conjunction with the Field Staff, Mr. Marriott tackled this aspect of the work which has yielded quicker results than the hybridization programme as far as resistance is concerned.

Unfortunately there seems to be a tendency for linkage of the factors for resistance, medium-sized boll, slightly shorter fibre than the mean of the variety, and a rather vegetative type of plant, in most of the resistant Miller selections he has been able to isolate. He is prosecuting this line of attack fairly fully, but it is believed that he may eventually obtain a superior type in respect to all of the factors mentioned by hybridizing Miller strains with the more open U.4. He is therefore carrying out as much work in this direction as he has been able under the war conditions. His assistant joined up with the R.A.A.F. early in the war and hence we have had to carry out a relatively modest programme in the hybridization work. It is hoped to expand this, however, this season, with temporary assistance during the main period of work.

Mr. Marriott has been able to make considerable progress, however, in the hybridization programme and some of his more uniform F_3's have yielded so well that the farmers who have grown small multiplication plots of them have been well satisfied. These strains need further purification, however, and he will be largely engaged in this work this season. Some of his F_3's which have shown only a moderate amount of jassid-resistance have given very promising results on forcing soils in districts where absolute jassid-resistance is not required. Consequently we are conducting in the Upper Burnett this season a fairly comprehensive trial of all his advanced strains and the main Triumph strains, in the hope that we may be able to eliminate Triumph, which has no jassid-resistance, for the fertile alluvials of that district.

It is realised that this may not be achieved and consequently Mr. Marriott started a Triumph jassid-resistance breeding programme by hybridization which he will carry on through the F_3's, and if it appears that a promising degree of uniformity of type is being obtained similar to that which was realised in three generations of Miller backcrossing, the Triumph hybrids improvement programme will be transferred to the Upper Burnett for Mr. Peters to carry out, who is responsible for the regular breeding work in that and all centres south of there.

Similarly, Mr. Marriott will study the possibilities of evolving a Lone Star jassid-resistant type through hybridization, for this variety reacts very severely to jassids and we have frequently lost the top crop of it in the Central Burnett.

It can be seen, therefore, that Mr. Marriott's main work is evolving a jassid-resistant type in Miller or in backcrosses of Miller. He will

also take advantage of the facilities available at the Station to study the possibilities of evolving jassid-resistant hybrids in other varieties. When he has sufficiently uniform material to allow of either mass selection of open pollinated material or single-plant selections yielding suitable strains, such material will be turned over to Mr. Peters to grow in either the Upper or Central Burnett where jassid-resistance is badly required, and only a limited area of soil is suitable for producing good yields of Miller.

Recommendations to farmers regarding the most suitable varieties to grow on the different soil types in each of the main districts have been issued. There is very little prospect of evolving extensive one-variety communities in each district, although we are endeavouring to achieve as much as possible in this direction.

It is hoped that this survey will give a general picture of the objects of the breeding work and of the part that Biloela is playing in the scheme.

COTTON RESEARCH STATION, BILOELA
PROGRESS REPORT FOR THE 1943-44 SEASON.

Introduction.

This progress report on the cotton investigations conducted at the Research Station during the 1943–44 season has been prepared from the reports submitted by the same officers as were responsible for carrying out the work in the two previous seasons.

Meteorology.

The rainfall from June 30th, 1943, to July 1st, 1944, totalled 28·69 inches or 0·44 inches above the mean for 1924–44 inclusive. The monthly distribution during the growing season was extremely variable—that for August to December inclusive being substantially above the means for these months. January received approximately half its mean, while 8 inches occurred in February as compared with the mean 4·91 inches for this month. The rest of the months received less that half their means, except May which had slightly above the mean for that month.

Temperatures as a whole were slightly above both the mean maxima and minima except in April and May, which were characterized by unusually cool nights with the first frost, a light one which killed most of the leaves, occurring on the 14th April—the earliest record for the Research Station.

Agricultural Practices.

The favourable rainfall during September, October and November allowed a fairly satisfactory planting timetable for all experiments. The resultant plant growth was rather luxuriant until January owing to the amount of rainfall experienced—even on first year cultivations after Rhodes grass—and by the end of December it was obvious that good rainfall would be required in January to bring the large, vegetative yet heavily-laden plants through without suffering considerable loss of crop. Unfortunately most of the January rainfall occurred in the first week, as a thunderstorm which further stimulated sappy growth of plant. No beneficial rain was experienced for the following five weeks and in rain-grown cotton all squares, bolls up to a week old, and many of the leaves were shed. The February rainfall was of a soaking type and caused rapid renewal of vegetative growth which, however, set a nice top crop on most areas. No further rainfall of consequence was received, and the very leafy plants rapidly depleted the moisture in the upper layers of soil—where much of the root system was located. The development of the top crop of bolls was therefore restricted by lack of moisture and, in addition, by unusually cool night temperatures in April and the light frost on the 14th of that month which killed the leaves. The yields from rain-grown cotton were thus well below the prospects existing at mid-January before the onset of stress conditions. The yield harvested from 76·5 acres of various types of experiments on a wide range of soil types averaged 586 lb. seed cotton per acre.

The results obtained in the various experiments relating to cultural practices are as follows :—

Time of Ploughing Rhodes Grass.—The advisability of practising the grassland-cotton rotation has been demonstrated over a series of years both at the Research Station and in commercial crops in the main cotton-growing districts. As the farmers have been loath to plough the old pastures until late autumn or early winter, the experiments at the Research Station have mostly been conducted on winter-ploughed grassland. Though cotton planted on late-ploughed grassland is generally almost entirely dependent on the rainfall received during the growing season, it was thought that the relatively high permeability of the soil would offset this hazard by allowing more efficient penetration of storm rains. Investigations have demonstrated, however, that when the moisture content of the top layers of clay loam soils approaches wilting point, an inch of rain only penetrates to a depth of 6 inches, even in cultivations in the first year after grassland, and that at mid-season early-planted cotton utilizes most of the moisture in the top 12 inches of soil during a fortnight of hot dry weather. Tests were therefore carried out to determine the merits of ploughing grassland at a time when it is possible to conserve the subsoil moisture resulting from the previous wet season, and thus make the following cotton crop less dependent on rainfall during the growing period. Accordingly, in the 1941–42 season the merits of August, 1940,

February, 1941, and June, 1941, ploughings of three-year-old grassland were tested. Yields of 827, 787 and 369 lb. seed cotton per acre respectively were obtained. Tests of the residual effect of the ages of cultivation in the 1942–43 season indicated that the crops on the areas ploughed in February and June, 1941, appreciably outyielded the crop on the August, 1940, ploughing. A further test of the residual effect during 1943–44 showed that the differences were small, actual yields being in the following declining order—June, February and August. The results as a whole are in keeping with previous findings, *i.e.*, newer cultivations tend to outyield older ones, but in some seasons the first year cultivation may not produce as well as the second year cultivations after grassland owing to a deficiency of nitrate nitrogen.

Further tests of the merits of late summer and early winter ploughed Rhodes grassland in the first year of cotton cultivation were made this season in conjunction with mid-September and early October plantings. Following the good rainfall in spring and early summer, the March ploughed areas, while containing significantly more moisture in the 18- to 36-inch zones, did not significantly outyield the June ploughed plots. September plantings significantly outyielded October plantings, however, with March ploughed-September planted plots giving an average yield of 1,131 lb. seed cotton per acre—the highest average yield obtained this season in any of the rain-grown experiments on the Research Station. June ploughed-September planted plots produced 942 lb. per acre. Evidence was obtained that the March ploughed areas had a significantly higher nitrate content in both the first and second 6-inch zones of top soil, under the favourable moisture conditions. The residual effect on the following two cotton crops will therefore be tested.

The results of this investigation to date confirm the hypothesis that grassland ploughed in autumn at the end of the wet season conserves a greater supply of subsoil moisture than it does if ploughed in winter, and this additional moisture improves yields of the following cotton crop. The earlier ploughing also hastens the decomposition of the grass stubble. This may reduce the ability of land in the third year of cultivation to produce a profitable crop of cotton in seasons conducive to high nitrification during the transitional period from the vegetative to the fruiting phase of the development of the plants. Accordingly the investigation will be modified to test the value of grain sorghum grown in the second season after grassland as a means of retarding nitrification and thus improving the prospects of good yields in the following cotton crop.

Rhodes Grass-Cotton Rotation.—Investigations in this long-term experiment were continued along previously reported lines. Once more cotton planted on cultivations in the first, second and third seasons following grassland outyielded crops planted on older cotton land. The declining order of merit of the crops grown on the former grassland plots depended on the age of cultivation, *i.e.*, 1st, 2nd and 3rd year respectively. Likewise, Triumph again slightly outyielded

Miller, thus confirming previous findings that a quick-fruiting variety on very fertile soils may give better yields in a season characterized by a wet spring and early summer, and a mid-seasonal "dry up."

Cross Harrowing Experiment.—Preliminary tests of the merits of cross harrowing cotton crops in the seedling stage have indicated that this operation can appreciably reduce cultivation costs. No data are available, however, as to the necessity or otherwise of thinning crops by hand hoeing after they have been cross harrowed two or three times. An old cultivation on which ample weed growth could be anticipated in a wet spring was therefore selected for a $3\times3\times3\times2$ randomized split plot experiment embracing planting rates of 12, 18 and 24 lb. delinted seed per acre which were subjected to three treatments, viz., cross harrowing when 2–3 inches tall and again when 4–5 inches tall; the above cross harrowings plus a third one when the plants were 5–6 inches tall; and non-cross harrowing but row cultivation in the normal manner.

It was found that the seedlings should be at least 2 inches in height before being cross harrowed unless a very good to excellent strike has been obtained. It is advisable, therefore, to plant at least 18 lb. delinted seed per acre, which gives approximately an average of 4 seedlings per foot of the row ($4\frac{1}{2}$ ft. row spacing) to ensure an ample strike before the harrows are first used. This harrowing should take place as soon as weed growth becomes noticeable, for the weeds are then small, shallow-rooted and easily destroyed. Subsequent cross harrowings can be made without too great a reduction of the original stand of cotton. The stand remaining after the third cross harrowing—approximately 2 plants per foot of the row—was very little greater where the planting had been at the rate of 24 lb. instead of 18 lb. of seed per acre.

Unfortunately the crop produced on this old cultivation under the irregular seasonal conditions was so poor that picking the individual plots separately was not warranted, so no indication of the yielding ability of the different treatments can be presented.

Irrigation Investigations.

The investigations into the merits of growing cotton with supplementary irrigation were continued this season. Following the disastrous loss of terminals caused by insect attacks in crops planted in early October during the previous dry spring, planting of this season's experiments was not started until mid-October. Substantially less terminal loss occurred although there was a tendency for the first planted experiment to suffer more than the later plantings.

Effects of Supplementary Irrigation.—The irrigation plots were planted after a 3 acre-inch pre-planting spray irrigation at mid-October, and the rain-grown plots five days later. Rain totalling 1·24 inches fell four days after the latter planting and ensured a good stand characterized by rapid growth in the seedling and vegetative phases

of plant development. Flowering commenced in both treatments on approximately the same date, but the larger plants in the irrigation plots produced significantly more flowers during the first fortnight. Subsequently there were no significant differences for five weeks, when the effect of the mid-season "dry up" caused a rapid decline to cessation of flower production in the rain-grown plots.

The irrigation plots received a 3 acre-inch watering on the 18th of January and an equal amount on the 2nd February. The value of the three waterings is indicated in the respective yields of 1,741 lb. and 653 lb. of seed cotton per acre.

Soil moisture and nitrate determinations were again carried out. The moisture determinations showed once more the need for ample supplies of soil moisture at planting time. Although the moisture content of the first 18 inches of soil in the rain-grown plots was at approximately field capacity at planting time, penetrating rains of 4·81 and 4·47 inches, respectively in November and December, wetted only an additional ten inches of soil to field capacity in this clay loam soil at the start of the fourth year of cultivation. The rank sappy plants produced under these conditions used most of the available moisture to a depth of 20 inches before 8 inches of soaking rains in February relieved the situation. Even this amount of rainfall could only restore the moisture content of the top 30 inches of soil to field capacity and this was also exhausted during the following five weeks of dry weather.

The 3 acre-inch preplanting irrigation raised the moisture content of the top 28 inches of soil to field capacity, which enabled the November rainfall to penetrate deeper than in the rain-grown plots—the first 33 inches of soil being at field capacity in the first week of December. The large, heavily-laden plants markedly reduced the moisture content of the first 30 inches of soil during January. Moisture determinations made after 3 acre-inch spray irrigations on the 18th of that month and on the 2nd February, provided confirmation of previous findings that when the moisture content of the top 18 inches of soil approaches wilting point, a 3-inch spray irrigation will only penetrate to this depth of soil.

The nitrate determinations confirmed the findings of last season that during the spring and early summer, the rain-grown plots contain appreciably more nitrates than the irrigation plots. In 1943–44 this may have been due to the higher nitrate content of the top 12 inches of soil in the rain-grown plots at the end of last season. The high moisture in these soils and the relatively high minimum temperatures during September and October may thus have created favourable conditions for early and rapid nitrification.

In the irrigated plots, the nitrate content of the top 6 inches of soil was relatively low—4 p.p.m. at the end of the previous season, 7 p.p.m. at the beginning of this season, and 13 p.p.m. at the end of November. Apparently the rapidly growing plants utilized the

available nitrogen very quickly. In the rain-grown plots, nitrate readings in the top 6 inches of soil were higher—8 p.p.m. at the end of the previous season, 23 p.p.m. at the beginning of this season, and 29 p.p.m. at the end of November. Later the rapidly growing and very vegetative plants reduced the nitrate content at all soil levels to practically nil during the dry period at the end of January.

Time of Irrigation Experiment.—The rank plant growth which occurred in the irrigation area last season as a result of the early December irrigation and prolonged showery conditions in the latter half of that month, raised the question as to the advisability of December irrigations. Accordingly an experiment embracing four irrigation treatments comprising different times of watering and various quantities of water at an application was conducted this season.

The yields did not indicate that any significant differences between treatments had been obtained. The highest yield was obtained, however, with the time-table of irrigations normally used, while the lowest yield was produced in the December-irrigated plots. The plant growth on the December-irrigated plots was excessively vegetative and had January been wet, very serious loss of crop from boll rots might have occurred.

The history of early December-irrigated crops in the two seasons indicated the inadvisability of irrigating at this period of the crop's development. However, a mid-October-planted crop experiencing a very dry November will probably require an irrigation at mid-December if the first half of that month is also hot and dry. Apparently if prolonged wet conditions follow this irrigation, there will be danger of excessively rank growth of plant developing with a consequent loss of crop. The possibility of avoiding the necessity for an irrigation in December by irrigating the crop early in November is, therefore, to be investigated in the coming season.

Irrigation Varietal Trial.—The results obtained in earlier varietal trials grown with supplementary irrigation on the Research Station, indicated that the Miller and New Mexico Acala cottons were the most suitable for the soils of this centre. Accordingly the trial this season embraced two commercial strains of Miller, 41.J—a partially jassid-resistant Miller strain, New Mexico Acala, and a strain of Rowden which had given encouraging results in the trial of the previous season.

A pre-planting irrigation of 3 acre-inches and two subsequent similar applications were required until 8 inches of rain fell in mid-February. Considerable plant growth developed after this rain group which, under the subsequent dry weather, required a $2\frac{1}{2}$ inch irrigation early in March to mature the crop.

No significant differences between yields were obtained, the range of yields being 1,822 lb. to 1,927 lb. seed cotton per acre with the three Miller strains actually leading. Indications were obtained,

however, that the Rowden strain tended to produce more flowers than other varieties during luxuriant growing conditions, but fewer after the onset of hot, dry weather. An earlier irrigation at the approach of hot, dry weather may therefore be beneficial for this variety.

Cotton Varieties.

The investigations which can be grouped under this general heading, consisted of the following experiments :—

Time-of-Planting Experiment.—The results of several varietal trials conducted on various ages of cultivation have, in past seasons, tended to indicate that a type of Miller which flowers earlier than the present commercial strains of this variety would be advantageous in seasons when October plantings cannot be effected. Whether or no such a type would also be suitable for October plantings is not clear. Accordingly a $2 \times 2 \times 5$ experiment embracing early-October and mid-November plantings of Miller and the quick-flowering Triumph was conducted on very fertile first-year cultivation following three years of Rhodes grass.

Unfortunately terminal loss was rather high in both varieties at both times of planting—approximately 43 per cent. in the October plantings and 75 per cent. in the November plantings. The combination of high terminal loss, fertile soil and abnormally wet early summer conditions, produced many malformed, vegetative types of plant, so that there was a premium on early planting and flowering. The October plantings produced an average yield of 783 lb. seed cotton per acre as compared with only 297 lb. in the mid-November plantings. Triumph outyielded Miller by 94 lb. and 64 lb. seed cotton per acre respectively in the October and November plantings. In size of boll and in fibre quality Miller is superior to Triumph. The results tend to confirm previously obtained indications that a slightly earlier fruiting and more open type of Miller possessing the other good qualities of the present strains would be desirable.

Main Varietal Trial.—As part of the investigations conducted to ascertain the most suitable type of cotton for the Callide Valley, an 8 variety $\times$ 4 replications randomized block experiment including a range of quick- to medium-fast-flowering varieties, was planted early in October on very fertile soil in the first year of cultivation following three years of grassland.

Flower counts confirmed previous findings, *i.e.*, the earlier-flowering types produced significantly more flowers until mid-seasonal stress conditions were encountered following on which their flowering declined more rapidly than in the slower-flowering types. As a whole, earlier-flowering types produced the most flowers to the end of January and also for the total period of counting.

Although no significant differences were obtained between yields at the first picking—which reflected the first 8 weeks of flowering—there was a distinct tendency for the heavier-flowering varieties to

produce the most cotton, except that the strain of Triumph which produced the most flowers during this period was fourth in yield at the first picking—possibly on account of its smaller bolls. The total yields for the season were roughly of the same order of merit as at the first picking and ranged between 736 to 907 lb. seed cotton per acre.

The outstanding feature of the experiment was the performance of Rowden 40–6–F.3 which produced the best actual yield at the first picking and for the season. This variety has a large boll containing fibre which compares more favourably with Miller than any of the other quick-flowering varieties so far studied on the Research Station.

Cotton Breeding.—The cotton breeding operations centred on the Research Station consist of (*a*) maintaining and improving the main commercial strains of Miller and New Mexico Acala for use in districts where the cotton jassid is not an important pest, (*b*) the development of jassid-resistant types by selection in the Miller variety, and (*c*) hybridizing Miller and non-resistant varieties with highly-resistant varieties which are not otherwise suitable for Queensland conditions. The first part of the work is carried out on farms located near to the Research Station where isolation is assured under rain-grown and supplementary irrigation conditions. The second part consists of isolating and purifying jassid-resistant types on farms which normally experience fairly heavy attacks of jassids. The hybridization programme is carried out on the Research Station until the hybrids are sufficiently advanced for releasing to district officers who can isolate and purify suitable types for their respective districts.

In both Miller and New Mexico Acala, field observations indicated that a greater uniformity of plant characters coupled with a slight improvement in general fibre quality had been obtained in an increase of a mass-selected stock. This material will therefore be increased in order to replace the present commercial stocks of these varieties. Promising results were also obtained in the block of progenies of the leading commercial strain of Miller. An increase in the fibre length and lint percentage of this strain is desirable, but difficulty has been experienced in past seasons in improving either character. Significant correlation coefficients of the order of ·65 were obtained for these two characters between open pollinated 1943 parents and 1944 progeny rows, although no other correlations in this variety and none in New Mexico Acala were obtained. A Miller strain trial conducted at the Research Station, which included five of the more advanced progeny increases and the two leading commercial stocks of the variety, failed to produce any significant differences in yields. It was apparent, however, that improvement had been obtained in the newer strains over the parent strain's lint percentage of approximately 35.

The jassid-resistant breeding programme was handicapped somewhat by the almost complete absence of jassids on the experimental plots. A strain trial of advanced hybrid strains, jassid-resistant Miller strains, and commercial stocks of Miller and of

New Mexico Acala, yielded results which indicated that in many characters the jassid-resistant material was as uniform as the commercial stocks. Apparently rigid selection for large-bolled types, together with the use of large-bolled strains as the recurrent parents, has resulted in the elimination of the small U.4 boll type. On the other hand, the flowering rate of the hybrids is much closer to the prolific U.4—a possible reflection of the search for high-yielding strains in the hybrid parent. Marked differences in shedding of the flowers occurred, however, and some strains which produced a large number of flowers did not yield as well as other strains which produced appreciably fewer flowers. Four hybrid strains significantly outyielded three of the commercial stocks.

The results obtained in multiplication plots and in a strain trial including the highly jassid-resistant Miller strain III–26 indicated its good yielding qualities. Accordingly it is being released for commercial production in the areas likely to experience serious jassid attacks. Improvement of boll size and length of lint is required in it, however, and progeny blocks of Miller selections showing promise in these respects were therefore grown on farms and tested for jassid-resistance. The lack of a sufficient jassid infestation handicapped the work, and selection had to be done mostly on the basis of general plant and fibre characters plus hair type distribution on the mid-ribs of the leaves. Five families yielded 36 strains which gave a mean lint percentage exceeding commercial Miller.

Difficulty was also encountered in eliminating material in the hybridization centre on the Research Station where only a very light attack of jassid occurred. A large number of hybrid selections and increases which were immune under the light attack had to be retained for further testing. The Rhodesian strains, a strain of Ferguson and the F_1's of these and commercial varieties all showed complete immunity, whereas all of the commercial parents of the F_1's exhibited slight to moderate reactions.

An interesting feature of the jassid problem is the severe jassid infestation of late plantings of irrigated cotton that has occurred at the Research Station. In an endeavour to obtain sufficient jassid infestation to test the resistance of the newer hybrid material, a late-planted irrigated area will be included in the coming season's programme.

Entomology.

The experimental plots were planted on good rains during the spring and made satisfactory growth until mid-January when stress conditions developed in all non-irrigated crops. Some thrips injury occurred in the seedlings, particularly in irrigated crops, and the terminal damage induced a certain amount of vegetative growth. During the season, three bursts of *Heliothis* activity took place, the first during December when October-planted rain-grown crops had just begun to square, the second in January and the third in late February. Only the first of these was important, for the very dry

conditions during January and February made it improbable that any squares then present on the plants would mature. In December, squares were destroyed and terminal damage adversely affected the structure of the plants. Jassids were numerous in November-planted plots in the irrigated area during late summer, and squares were shed freely at a very early stage in their development. It seems unlikely that these insects were responsible for the phenomenon ; mirids may, however, be implicated for they were more than ordinarily abundant in the crop.

The experimental programme was designed to investigate (*a*) the effects of planting dates on the incidence of *Heliothis ;* (*b*) the control obtained with insecticides on crops planted on soils of different ages ; and (*c*) a straight comparison of 1–1–3 and 1–1–6 lead arsenate-molasses sprays applied with a Barbour mechanical spraying machine during bursts of *Heliothis* activity.

When the main *Heliothis* outbreak occurred in December, only the October-planted plots had reached the squaring stage. Egg-laying was consequently much greater on these than on the later-planted crops. However, in all three bursts of egg-laying during the season, the crop which was squaring most freely invariably received the greatest number of eggs.

In the second experiment, the experimental area included rain-grown cotton planted on a range of soils with widely different cultural histories. As would be expected, increased yields were obtained from the younger cultivations. Differences in yields could not be assigned to the insecticides applied during the growing period. As already indicated, the main outbreak of *Heliothis* occurred during December when squaring had just commenced. At that time, it was assumed that even relatively severe damage would be unimportant. Dry weather conditions in late January and early February prevented any extensive setting of squares appearing on the plants and indifferent crops were obtained. There is little doubt that a continuous cover of an arsenical dust or spray must be maintained on the plant when young larvæ are emerging from the eggs. Regular egg counts enable the entomologist to define this period with considerable accuracy ; it remains, however, to determine whether or no the arsenical will give effective control when properly applied. The capricious seasons in Queensland make it essential too that any severe outbreak after the commencement of squaring should be controlled.

The same problem occurred on irrigated plots treated with the identical insecticidal schedules and significant differences in yields were not obtained, although an average yield of 1,731 lb. seed cotton per acre was produced.

In another experiment, two spray concentrations were compared on an October-planted crop. The only well-timed and applied treatments were made during the minor peaks of *Heliothis* activity during January and February. The damage was slight, and considering

the blanketing effect on yields of stress conditions during the growing period, differences between treated plots were not expected. In actual fact, however, greater yields were obtained from the sprayed plots though these were not statistically significant.

EXPERIMENTAL PROGRAMME FOR THE SEASON 1944-45.

The programme proposed for 1944–45 embraces the following investigations :—

Agricultural Practices.—A continuation of the general programme reported upon for the 1943–44 season with modifications in the experiments relating to both non-irrigated and irrigated cotton, to embody amplifications indicated to be desirable, based on the results obtained in this past season.

Cotton Varieties.—The work under this grouping will be :—

(*a*) A continuation of the testing of the merits of varieties thought to be suitable for conditions of the Callide Valley and similar districts.

(*b*) The testing of the merits of strains developed in the breeding programme conducted on or from the Research Station ; and

(*c*) Furthering the programme of developing jassid-resistant strains in the major commercial varieties grown in the State.

Entomology.—The programme on the Research Station is much the same as last year, and is designed to assess the value of insecticides in controlling *Heliothis* when they are applied during, and for a short period after, each burst of egg-laying. Three experiments are laid down :—

(*a*) A time-of-planting experiment in which *Heliothis* activity will be recorded in crops sown in early October, early November and early December.

(*b*) An insecticidal experiment superimposed on a time-of-planting experiment, the insecticides including dusts and sprays applied at short intervals during, and for a short period after, bursts of egg-laying.

(*c*) An insecticidal experiment superimposed on two items of planting in irrigated cotton, the insecticides to be applied as in (*b*).

(*d*) Exploratory tests of D.D.T. as an insecticide for use against *Heliothis*.

SOUTH AFRICA

SEASON 1943-44.

Introductory Note

BY
F. R. PARNELL.

Staff.

Barberton.—The staff remained the same for the season, but has now been increased by the return of Mr. Rose, who was released from Military Service in October. Arrangements have been made for Mr. H. E. King, of the Sudan Department of Agriculture, to remain with us for the coming season.

Swaziland.—The position remained the same as last season, with both Mr. Lochrie and Mr. Hutchinson working under the Administration.

Commercial Crop.

The acreage was slightly less than that of the previous season, but yields were better and the total production greater, though still extremely small. A slightly higher price, 8¾d. per lb., was obtained for the crop, but this is still low in comparison with other farm produce and is unlikely to lead to any substantial increase in the acreage planted in the coming season.

Experiment Stations.

Barberton.

With a good season, growth and yields of cotton were very satisfactory and excellent progress was made in the work generally. It is unnecessary to refer here to the circumstances determining the programme of work now being carried out, since these have been described in earlier reports and in a note on the Low Veld written last year. There are two main lines of work in progress, cotton breeding with hybrid material and a study of the relationship between hairiness and jassid-resistance.

Cotton Breeding.—Briefly, the chief object of the breeding work is to produce a type of cotton thoroughly suited to short-season conditions, highly resistant to jassid, and giving lint of substantially higher spinning quality than can be obtained inside U.4. In the crosses now on hand, U.4 and M.U.8 have been used as parents to bring in hairiness and good field characters, the high quality of lint being derived from several *hirsutum* varieties and also the *barbadenses*, Sea Island and Egyptian. It is too early yet to say which are the most promising.

It was originally anticipated that the inter-specific *barbadense* crosses might give trouble by continuing to break up into useless types. Such a break-up has occurred in much of the material, but there is also much that is very promising. It is difficult material,

requiring large-scale working to give much hope of success. It has been given as much room as could be managed, 12 acres in the past season and 16 acres for the coming crop, with every feeling that it is worth the labour involved.

The U.4×Cambodia crosses form a separate group, originally intended for the improvement of U.4 hairiness. Their excellent early promise has been fully maintained in a variety trial this year and their spinning test results are awaited with interest. If their lint proves satisfactory and they maintain their good record in the coming season, there will be every reason to hope that the best of them will be a decided improvement, for general cultivation in the area, over our best U.4 strains.

Jassid-resistance.—A critical examination is in progress of the relation between hairiness and jassid-resistance. This is a somewhat controversial question on which conflicting reports exist, and well-established facts are urgently required to clarify the whole subject.

The past two seasons' results here have demonstrated, beyond any shadow of doubt, that, in these conditions and in the wide range of varieties investigated, an extremely close connection exists between leaf-hairiness and jassid-resistance. All the results so far obtained suggest that the hairiness itself causes the resistance.

Our evidence shows clearly that hairiness of stem is not essential for even a high degree of resistance. This also appears to hold true for hairiness of petiole, so far as the available evidence goes. The results reported for leaf-hairiness are based on lamina only, this being chosen for the sake of convenience. The degree of importance attaching to hairiness of midrib as compared with that of lamina has not been thoroughly examined, but will form one of the main subjects of investigation in the coming season.

A matter of particular interest is the gradual development of hairiness in the young plant. This means that a variety classed as highly resistant may be severely damaged if exposed to a heavy jassid population whilst still young, before its hairiness has developed appreciably. It is possible that a critical examination of some of the conflicting reports on jassid-resistance might show that this factor has been responsible for seeming anomalies.

The work on hairiness and jassid-resistance has not by any means reached a final stage and must be continued. Certain details and results are of sufficient interest and importance to be published immediately, however, and they are given in Part II of this report.

Swaziland.

Both at Bremersdorp and at Croydon the main work in progress is concerned with problems of fertility and soil treatment. The need for this is apparent from Mr. Lochrie's introductory note, which

stresses the haphazard nature of native agriculture and the difficulties arising from this.

For some years past the Stations have been concerned increasingly with general agricultural problems and this will be the more so now that Mr. Lochrie has taken charge of the whole farm at Bremersdorp. The grass work, which is well started there, forms an important part of the attempt to work out a sound system of crop rotation and resting of land. All this is long-term work which will need to be prosecuted energetically for some years if full value is to be derived from it. There is no doubt that it is urgently needed in the country.

COTTON EXPERIMENT STATION, BARBERTON. PROGRESS REPORT FOR THE SEASON 1943-44

BY

D. MACDONALD, D. F. RUSTON AND H. E. KING.

PART I.

INTRODUCTION.

The proposed programme of work for the season was carried through satisfactorily in good conditions.

As previously reported, breeding work within the U.4 type has been discontinued, since further progress would be slow and limited. This work is now confined to hybrid material, resulting from a large number of crosses. In most of these a parent possessing high quality of lint has been used on one side, since it is in this direction that improvement is particularly needed.

Investigations into the relationship between jassid-resistance and different types of hairiness were continued, together with further studies on the development of length and density of leaf hairs during the growth of the cotton plant.

Jassids were present in sufficient numbers to enable this investigation to be carried out satisfactorily, although the commercial crop suffered no damage. Damage from other pests was negligible and, although stainers were present quite early in the season, the incidence of internal boll disease was very low.

METEOROLOGY.

The total rainfall for the year was 33·28 inches, slightly above the average. Of this total, over 6 inches fell in August–October, so that by planting time, early November, the reserve of sub-soil moisture was better than usual. Apart from a hot dry December, which benefited the cotton by stimulating early fruiting, the rainfall was well distributed through the season.

Genetics and Breeding.

Variety Trial.—A balanced incomplete block trial, containing 37 strains by 9 repetitions and covering 8 acres, was carried out to compare the yields of thirty U.4×Cambodia and two U.4×M.U.8 strains with the five best U.4 strains, including 5143, the strain in general cultivation in the district. Growth was good and insect damage very light, high yields being obtained. The mean yield of 494 lb. lint per acre from all varieties, reflects the general excellence of the strains, even if allowance is made for the good conditions during the season.* Individual yields, in lb. lint per acre, ranged from 408 to 632, with a difference of 60 required for significance at P=·05. Within the U.4 group, 5143 was significantly outyielded, for the third year in succession, by two newer strains from other families. (One of these would possibly replace 5143 in general cultivation if some of the Cambodia crosses were not so promising.) Of the Cambodia crosses, six were significantly better than the best U.4 strain, whilst 21 of these and both M.U.8 crosses gave yields significantly higher than 5143.

It may be noted of the Cambodia crosses that sister strains of the same family tended to give similar yields. Thus three families, represented by eight strains, fell into compact groups among the ten highest yielding strains of the trial. This is particularly satisfactory from a breeding point of view.

To illustrate the general results of the trial, mean figures are given below for the U.4. strains and Cambodia crosses separately, also for the best six of these crosses.

	Yield of Lint, lb. per acre.	*Ginning %*	*Seed Weight.*	*Lint Length, mm.*
Mean of five U.4 Strains	450	37·0	8·5	31·1
„ „ thirty 5143×Cambodia Strains ...	501	35·2	10·9	32·4
„ „ six best 5143×Cambodia Strains ...	575	35·7	11·0	33·6

The excellent results given by these crosses are very evident. Further reference to them appears in the section that follows.

Hybridization.

U.4, 5143×Cambodia.—This material, now in F_5, is made up mainly of the thirty strains appearing in the variety trial above. They cover a wide range of types, but in general are rather stronger than the U.4 parent, whilst maintaining great fruitfulness, as shown by their yields in the trial. They are all very highly resistant to jassid, being decidedly more hairy than U.4 strains. A.2106, which appears in the photographs of hairs (*see* p. 29) is one of these strains, which gave the highest yield in the variety trial. Lint lengths are generally good, particularly in some of the highest yielders which show an appreciable improvement on U.4. Samples for spinning tests,

* The crop itself was not manured, but the previous crop of maize had received 200 lb. per acre of superphosphate.

taken from the variety trial, have been sent of twelve of these strains, the two M.U.8 crosses and four U.4 lots, to obtain a general comparison.

The best 19 strains, judged on all characters, are being carried forward as large selfed bulks in the coming season, when further single-plant selections will be made. It is hoped that the spinning test results will be received in time for use as a guide in this work. Care will be taken to maintain a wide range of types, thus reducing the likelihood of over-specialization giving types suitable for local conditions only.

Five of the strains have been crossed by selected Uganda B.P.52 plants, in an attempt to improve their lint quality.

U.4, 8161 × M.U.8.—This group is somewhat similar to the above Cambodia crosses. It gives rather better hairs, but good lint is less easy to find and ginning percentages are generally lower. In spite of this, the material is promising and many good selections have been made, 65 single plants and 27 special bulks being carried forward for the coming season. Twelve of these bulks will be included in a variety trial with the four best U.4 strains.

Quality Crosses.

The main objects of this series of crosses were given in the previous season's report.

U.4 and M.U.8 × Coker Wild's.—A three-acre block of this material was grown, comprising 94 single-plant selections from F_2 and several bulks from backcrosses. The material as a whole was unattractive: there were very few plants showing a combination of good hairs and good lint and none of these possessed good field characters. In view of this general lack of promise, in comparison with other crosses made with the same object, the whole material has been discarded.

Other Hirsutum Crosses.—U.4 and M.U.8, as hairy parents with good field characters, have been crossed with the following types carrying high quality lint:—B.P.52, Meade, Tidewater and Gen.33 (one of Harland's strains).

Large F_2's, about $\frac{1}{4}$ to $\frac{1}{3}$ acre, were grown of each and special bulks taken for carrying forward. These bulks were made up of selected plants, roughly 5% to 8% of the whole, showing a combination of good hairs and good lint with reasonable field characters. 5143 × Tidewater was discarded as unpromising: the other lots gave material of a high standard. These bulks will be treated in the same manner in the coming season and will also be put into a variety trial with U.4 strains, to test their general productiveness, before single-plant selection is started.

The F_1's of the above crosses of Meade and B.P.52 were backcrossed to B.P.52 selected hairy plants. The latter possess the best combination of good hairs and lint quality at present available and the backcrosses should show improved lint quality without a corresponding loss in hairiness.

U.4, 8161 × Sea Island and Egyptian.—A total of 340 single-plant selections, the F_4 from these two crosses, occupied 12 acres. Of the above total by far the larger proportion were derived from the Sea Island cross.

As was to be expected, many progenies were very mixed and showed a wide variation in hairiness, lint, and general field characters, although the proportion of plants useless from an economic point of view was very markedly less than in the preceding generation. On the other hand, there were many progenies which, although not by any means uniform, contained a large proportion of plants with the combination of long silky lint and much better leaf hairs than U.4, associated with prolific fruiting and other desirable field characters.

The high standard of fruiting in many good lots is most encouraging, though it was no doubt helped by the good season and probably also by hybrid vigour, which will diminish in ensuing generations. The main difficulty experienced so far is that many of the best lots are on the late side. Early-maturing types can be found, but there is a tendency for these types to be associated with lint that is shorter and harsher than the standard aimed at, and it remains to be seen whether this tendency can be broken effectively.

In all, 509 single-plant selections are being carried forward for planting next season, the majority again being from the Sea Island group.

Hairiness and Lint Characters.—A further attempt to determine whether selection for hairiness of plant would be likely to result in a marked loss of lint quality was made, using the F_2 of a cross between Sea Island (non-hairy, long fine lint) and M.U.8 (very hairy, rough short lint).

Hair measurements from photographs of leaf lamina were obtained from some 200 plants, together with lint length measurements on combed seeds, and a rough judgment of relative " fineness " based on the " feel " of the ginned lint. A field description of stem hairiness was also available.

Over the extremely wide range in both leaf hairiness and lint length amongst this material, no correlation whatever could be detected between either density or length of leaf hairs and lint length or " fineness." Stem hairiness also appeared to be entirely unrelated to lint characters.

Leaf Hairiness and Jassid Resistance.

Work was continued during the present season on a study of the relationship between hairiness of the leaf lamina and jassid-resistance, the methods used being described in Part II.

Hirsutum Strains.—Thirteen *hirsutum* strains, covering the widest available range in hairiness, were planted in a replicated experiment. The trial was interplanted with jassid-susceptible cotton, with the

HAIRS AND JASSIDS

HIRSUTUM STRAIN TRIAL

STRAIN		JASSIDS PER 1,000 LEAVES
M.U.8.		3
A.2106		32
U.4 5143		137
B.P.52 L.H.		462
MEADE		1,409
COKER WILDS		2,586

SCALE 0 1 2 MM.

dual object of increasing jassid infestation and of spreading it as evenly as possible over the whole area.

Counts of jassid nymphs were made weekly throughout the season on 100 leaves per strain, while in mid-season lamina strips were taken from a fixed leaf (the 8th leaf from the top down the main stem) on 32 plants in each strain. Hair counts and measurements obtained from these strips were used for correlation with the jassid counts.

A very high correlation ($r = -0.951$) was found between average number of jassids per strain and average density of hairs reaching a height of 0·3 mm. (both on a square root basis). The two most susceptible strains, Tidewater and Acala, could not be included in this correlation, their hairiness being insufficient to justify the taking of photographs. They fitted very well into the general picture, however, having more jassid and less hairs than Coker, the lowest density photographed.

Plate I shows photographs of typical lamina strips, together with jassid count figures, for six strains covering the range used in the correlation. From this the close general connection between hairs and jassid is very obvious.

There appeared to be certain minor discrepancies, when figures for strains near together in the hair range were compared. These might well be due in part to errors in sampling, particularly in the less uniform strains. It is possible, however, that differences in hairiness of *midrib* were also concerned, and preliminary records on this character support this possibility.

Hirsutum × *Barbadense Single Plants.*—Following on last season's results on single plants from *G. hirsutum* and *G. barbadense* crosses, a whole field was sown with a mixture of seed from this material. Single plants, covering the widest possible range in both density and length of hairs, were marked early in the season for jassid counts, while in mid-season *lamina* strips were taken from four leaves on each plant.

A total of 165 plants came through the season and gave jassid counts on 11 separate dates, the equivalent of 88 leaf counts per plant. Analyses of the results obtained from these plants were carried out in many ways, all of which emphasised the close connection between jassid numbers and leaf hairiness. More details of the results obtained from these figures are given in Part II, but it may be stated here that the coefficient of correlation between jassid numbers and density of hairs at a height of 0·4 mm. was −·842 for the 165 plants taken separately. This high and extremely significant correlation indicates that, whatever the underlying mechanism connecting hairiness with resistance, a simple measure of lamina hairiness can account for over 70% of the plant-to-plant variance in jassid infestation.

A correlation of —·981 was obtained, using group means, when the plants were divided into 10 groups according to their density at 0·4 mm. This figure is more comparable with that obtained in the *hirsutum* strain trial, as, in both cases, averaging the results obtained from single plants has greatly reduced the effect of errors in jassid and hair sampling, and also the effect of other possible factors which may affect plant-to-plant variation in jassid counts.

In general, a hairy lamina is associated with a hairy midrib. It is, therefore, difficult to determine which of the two is more important in conferring resistance to jassid. Towards the end of the season photographs of typical *midribs* (one per plant) were taken on 42 single plants. Many of these were selected as having more or less jassid than was to be expected from hair records on the lamina. In this group of plants the correlation between midrib hairiness and jassid numbers was considerably greater than that between lamina hairiness and jassid. This preliminary indication of the importance of midrib in jassid resistance will be followed up next season.

Experiments.

Minor Elements.—An experiment was carried out on the red loam soil to test the effect of various minor elements, potash, and dolomitic limestone on the general development of the cotton crop and, more particularly, on the early closing-down associated with *Alternaria*.

The elements used were boron, copper, zinc, magnesium and manganese, applied individually and in combination with and without potash : potash alone and dolomitic limestone at three tons per acre formed separate treatments.

Initial stand and growth were good. Green-weight samples, at 46 days from planting, showed the best growth from potash and the poorest from dolomitic limestone.

On all plots not receiving potash, growth fell away early, whilst growing conditions were still good, and *Alternaria* spread rapidly. Plots receiving potash, either alone or in combination, maintained their growth a few weeks longer, but finally went off with *Alternaria* in the same manner. This extra growth increased their mean yield to 1,080 lb. per acre of seed-cotton, compared with a mean of 485 lb. from all others.

None of the minor elements appeared to have any effect on growth, yield, or *Alternaria*, and the only effect of the limestone was a slight depression of early growth. The same elements had been tried several years ago and gave no effect on growth or yield, but *Alternaria* did not develop in that season. Work with these elements, therefore, will be discontinued, but the effect of different levels of potash supply, at various times of application, will be investigated in the coming season.

Soil-Structure.—From figures given in last year's report, it is evident that the "crumb-structure" of our red loam soil has deteriorated during cultivation over a number of years. A 4-acre block of newly-ploughed grass land was planted, half to cotton and half to maize, and will be continued in a cotton–maize rotation. Soil samples will be taken annually to follow the effect of cropping on crumb-structure.

A point of interest that should be mentioned is that the cotton on this land finished out very well, giving about 1,500 lb. per acre of seed-cotton from very moderate growth, and was not attacked by *Alternaria*. The exposure to infection would be less on this block—next season a plot will be sprayed with a suspension of spores.

Grass Rests.—An experiment has been started on old land to test the effect of two-year and three-year resting periods under Napier and Rhodes grasses, both in improving crumb-structure and on the growth of succeeding cotton and maize crops. Dr. W. S. Martin, of the Kawanda Agricultural Research Station, Uganda, has very kindly undertaken to carry out examinations of the structure on annual samples from this experiment.

ROTATION CROPS.

Experimental work was confined to streak-resistant types of maize bred on the Station. The heaviest attack of streak ever experienced here was recorded this season. Normally, damage is mainly suffered by medium-late and late-planted maize, but this season appreciable damage was done to susceptible types planted in early November.

Two trials, one early- and the other late-planted, were carried out comparing streak-resistant types with their parent varieties. Streak-resistant types bred here normally yield significantly less than their susceptible parents in the absence of streak, and are mainly useful for late plantings when streak is prevalent. This season the early attack ot streak was such that in the early-planted trial the best streak-resistant type, a Hickory × Peruvian strain, was not significantly lower in yield than Hickory, the highest yielding susceptible parent. In the late trial, streak damage to Hickory was so great, 98% of the plants being attacked, that it yielded only 337 lb. grain per acre, compared with 1,278 lb. from the Hickory × Peruvian resistant type.

Since 1940, shortage of staff has reduced all breeding work on streak-resistant types to a routine rogueing of resistant bulks already produced. Further crossing work, to improve yield capacity without losing resistance, will require more time than the present staff can devote to it. In view of the urgency of this need, due to the widespread incidence of the disease from Natal to the Northern Transvaal in recent years, all available streak-resistant types bred here have been handed over to the Union Department of Agriculture for further work.

PROGRAMME OF WORK FOR 1944-45.

Cotton Breeding.

Variety Trials.—Three trials as below.

(1) 25 Strains—19 of U.4×Cambodia, 2 of U.4×M.U.8, 4 best U.4 strains.

(2) 15 Strains—11 of U.4×M.U.8, 4 U.4 strains as above.

(3) 10 Strains—7 Special Bulks from F_2's of *hirsutum* quality crosses, 3 of above U.4 strains.

Hybridization.—Work will be continued on the material described in the present Report. Nearly 800 single-plant selections and a large number of bulks have been carried forward.

Hairiness.—The photographic method of analysing hairiness will be employed in a continuation of the study of variation on different parts of the plant, mainly leaf lamina and midrib, at successive stages of growth and in different growing conditions.

Jassid - Resistance. — The relation between hairiness and jassid-resistance will be further investigated, both *hirsutum* types and *barbadense* crosses being used for the purpose. Hairiness will be measured on both leaf lamina and midrib. These two characters are commonly closely related, but certain types appear to be aberrant in this respect. Particular attentions will be paid to such aberrant types in an attempt to separate these characters in their relation to jassid-resistance.

Experiments.

Alternaria.—A manurial experiment has been laid down to compare the effects of different levels of potash supply, at various times of application, in retarding the onset of *Alternaria*. A 10-ton dressing of compost is also included, both alone and in combination with a medium potash dressing.

Soil Structure.—The experiment to test the effect of resting crops of Napier and Rhodes grasses on the red loam soil, now in its second year, is being continued.

PROGRESS REPORT—PART II

BY

H. E. KING AND D. F. RUSTON.

Technique Employed in Studying the Hairiness of the Leaf Lamina.

The technique at present employed in studying the hairiness of the leaf lamina differs in some important points from that outlined in the last report. Although not yet entirely standardized in all respects, it would appear to be worth a brief description here.

Sampling.—The very marked leaf-to-leaf variation, consequent on plant development through the season (see a later section), necessitates a very careful choice of leaves to provide a representative sample of the plant. In comparing strains or varieties, one standardized leaf per plant has been taken from as many plants as possible, to smooth out the plant-to-plant variation. For studying the relationship between hairs and jassid infestation on individual plants, the sample was increased to four leaves per plant, taken to represent as far as possible those utilized in jassid counts.

The sampling of the leaf lamina was carried out as last season, by cutting a narrow strip from a standard position between the veins of the central lobe. A simple cutter consisting of two parallel razor blades was used in the field without detaching the leaf. For the majority of the work, the width of strip used was 0·7 mm. With the method now adopted for recording the hairs, however, a somewhat wider strip (*e.g.*, 1·3 mm.) may be used with advantage.

Recording the Hairs.—In place of last season's direct microscopic examination of the lamina strips, a permanent photographic record of the hairs was obtained by inserting the fresh strip in an enlarger and throwing a silhouette of the hairs in profile, at a magnification of ×10, direct on to bromide printing paper. Using this method, up to 240 leaves were handled in one day, and some 3,000 dealt with during the season.

Working from the photographic records, it is possible to obtain estimates of the density and length of hairs comparable with those given by direct microscopic examination of the material. In addition to greater rapidity and ease, this photographic method possesses the advantage of furnishing a record which may be studied at leisure in numerous alternative ways. When required, positive prints, as shown in Plate I, may easily be obtained by using the original as a negative.

Analysis of Hair Records.—A prolonged and detailed study of the records made available by the technique outlined above, has led to important conclusions as to which measurable characteristics of the lamina hairs are of the greatest practical value.

Previous work had already indicated the importance of both length and density, but had also raised doubts about the value of figures for *mean* length and *total* density based on every hair visible, no matter how minute. Numerous extremely short hairs often exist as an " undergrowth " beneath the longer ones, inflating the figure for density and decreasing the mean length. It was thought that a method which ignored hairs below a certain length might well prove of greater value in studies of jassid-resistance. For such purposes, also, a *single measure* reflecting both length and density, has obvious advantages.

Such a figure may very easily be obtained from photographs of lamina strips, if the measurement of hair *length* is abandoned in

favour of that of *height*, measured at right angles to the lamina surface. Thus, taking for instance a height of 0·2 mm., a count may be made of all hairs crossing a line this distance from the surface of the lamina. Hairs not crossing the line (whether erect or spreading) are ignored, and the result is a figure representing the density at a height of 0·2 mm. Density at progressively greater heights, 0·3, 0·4, etc., according to the distribution exhibited, may be obtained from the same photograph.

Studies of data obtained in this way, in comparison with numerous alternative measurements, have indicated very strongly that a single count of hairs at a suitable height gives a simple measure of jassid resistance, which, for practical purposes, cannot be much improved upon. Over a wide range of hairiness, the density at a height of 0·4 mm. has been found the best single figure : it is this which has given the high value, quoted in Part I, for correlation with jassid counts, on a single-plant basis.

Were it not for the results obtained, it might well be argued that this method is an over-simplification of the problem of expressing " hairiness " numerically. A somewhat better prediction of jassid infestation may, in fact, be obtained by taking into account more than one measure. Thus, in place of a simple regression of jassid on density at 0·4 mm., a multiple regression equation based on densities at heights of 0·3 and 0·5 may be used. In this way, with the 165 plants, the proportion of the variance accounted for was raised from 71 to 74%.

Since, however, it is not to be expected that a count of nymphs, under conditions of natural infestation in the field, is an *exact* measure of relative susceptibility, and since it is unlikely that hairiness of leaf lamina is the *sole* factor in jassid-resistance, an elaborate formula giving a truer measure of lamina hairiness is not necessarily of much practical advantage.

A more useful method of distinguishing finer degrees of resistance would appear to lie in chosing the single measure best suited to a particular body of material covering a smaller range. It has, in fact, been found that the density at a height of 0·5 mm. is better for differentiating between plants of moderate to good resistance, while degrees of susceptibility in plants possessing few or no hairs of this height, may be distinguished by reference to the density at a height of 0·3 or even 0·2 mm.

For all the statistical analyses carried out, the measure of relative jassid infestation used has been the square root of the count of nymphs per unit area of leaf surface. The crude figures from leaves of various sizes were converted to a standard area. A square root transformation of the hair counts also, has been found to render the relationship more nearly linear.

Plant Development and Leaf Hairiness.

More detailed results were obtained this season on the changes that take place in leaf lamina hairiness during the growth of the plant.

On 10 plants in each of two strains, M.U.8 and 5143, records of density and length of hairs were obtained on alternate main stem leaves throughout the season. The counts and measurements of hairs were made under the microscope, on lamina strips taken when the leaves were fully grown.

The main results are given in Table I and clearly reveal the gradual building up of hairiness over a long period. From the Table it appears that density per square mm. increases steadily with the growth of the plant, but in reality this increase can be divided into two parts. Up to about node 16, the increase in density corresponds with an increase in hairs per leaf, while after this point it is due to a decrease in leaf size, hairs per leaf remaining constant. Hair length, on the other hand, appears to reach a maximum at about node 14 and thereafter shows a tendency to drop slightly.

TABLE I.

HAIR DEVELOPMENT DURING PLANT GROWTH.

LEAF LAMINA; MEAN OF 10 PLANTS PER STRAIN.

Node No. on Main Stem.	*Days from Planting.**	*5143.*		*M.U.8.*	
		Density per sq. mm.	*Average Length, mm.*	*Density per sq. mm.*	*Average Length, mm.*
Cotyledon	—	Nil	—	Nil	—
2	—	0·1	·31	0·2	·44
4	—	0·2	·33	0·5	·51
6	—	0·6	·44	1·1	·61
8	53	1·1	·47	2·1	·69
10	60	1·9	·53	3·0	·80
12	67	2·6	·53	3·9	·86
14	81	3·0	·58	4·6	·90
16	95	3·8	·58	5·1	·83
18	104	4·2	·57	5·6	·84
20	114	5·1	·54	5·8	·79

* When leaf was fully grown. Figures not available for early leaves.

It is evident from these figures that leaf hairiness varies enormously during the life of the plant, particularly in the early stages of growth. The range of hairiness on a single plant of M.U.8, for instance, is greater than the total range between varieties shown in the photographs in Plate I.

If leaf hairiness is the main factor in jassid-resistance, the lower degree of hairiness in the young plant should make it more susceptible. This would explain the fact, generally reported from India, that late-planted cotton is more susceptible than early-planted. In a preliminary examination of this point, a few rows of cotton (3 varieties) were planted alongside the jassid variety trial, but two months later. Jassid counts on this late-planted cotton, compared with those on the same varieties in the trial, for the same period, gave the following results :—

JASSID PER 100 LEAVES.

(Average of 6 Weekly Counts.)

Strain.	*Early Planted.*	*Late Planted.*
M.U.8	0·3	36·3
P.43F	7·8	95·0
5143	14·8	222·0

With all strains infestation was markedly higher in the late-planted cotton. Late-planted 5143 had almost as many jassids as early-planted Coker (*see* Plate I) and, under these conditions, would be classed as a "highly susceptible" strain. It did, in fact, show serious damage and never fully recovered from this heavy infestation. The difference in planting dates would be the equivalent of about 10 nodes on the main stem.

Hair Development and Leaf Size.—Lamina samples from the same leaves, taken at different stages of growth, indicate that hairs are fully formed, as to both numbers and length, in the very early stages of leaf development, further increase in leaf size merely reducing the density per unit area. This held good with the youngest leaves sampled, which averaged only 6 sq. cm. in size.

SWAZILAND

INTRODUCTORY NOTE AND PROGRESS REPORTS FOR THE SEASON 1943-44, FOR THE COTTON EXPERIMENT STATIONS.

BY

J. V. LOCHRIE.

The Potential Cotton-Growing Area of Swaziland.

The cotton-growing area of Swaziland forms part of a strip of country running from the Eastern Transvaal into Natal. This area and its cotton-growing problems has been described by Mr. Parnell in his " Note on the South African Low Veld " already issued by the Corporation.

Swaziland differs only in respect of having a considerable native population living on their own land, and a note on the agricultural system and practices of the Swazi is given here.

The Native Reserves comprise about 40% of the total area of Swaziland and are scattered more or less evenly throughout the country. The average holding per family is about 60 acres and this carries 12 head of bovine stock and, in addition, a fair number of small stock are kept. The cattle population is increasing considerably and overstocking is general, while the human population is estimated to be increasing by 2% per annum.

The Swazi is primarily concerned with his cattle, and numbers are revered above quality. No attention is paid to management of the grazing or of the cattle, and the standard of the herds must further deteriorate. The main causes are overstocking and too early breeding. Evidence of the poor nutritional status can be seen in the improvement which takes place in young stock purchased from Natives and grown out on the relatively better conditions of European ownership. The poor conditions for stock are serious from the point of view of production of animal products, but are immensely more serious in their effect on the vegetation and on the soil. Measures to limit stocking to a safe rate and to ensure some form of grazing control are of vital importance before the position becomes calamitous.

The growing of crops is a disagreeable duty undertaken by the Swazi to obtain food supplies and it is done in primitive and inefficient ways. The average amount of land ploughed is 4 to 5 acres per family, and this is almost entirely devoted to cereal crops. Food production is commonly less than enough for his needs and the family income is supplemented by occasional sales of cattle, by the sale of cream, and by employment on farms and other local enterprises, and also in the mines in the Union of South Africa. Many families are unable to supplement their income and malnutrition exists, as much from actual food shortage as from lack of variety in the diet.

The farming system is based on shifting cultivation with cultivation devoted almost entirely to cereals. In earlier times choice of land was

less limited and food requirements could be met fairly easily. As less land became available the productivity decreased through a number of factors such as infestation by witchweed, fertility decline following cropping without any return to the land, and through erosion.

In addition to the main crops—maize for food and kaffir corn for beer making—a fair number of others are grown, either alone or in mixtures. These are beans, mainly *Vigna*, Ndhlubas (*Voandzia*), groundnuts and occasionally some *Phaseolus*, while pumpkins, melons and a little sesame are also cultivated. However, these are in relatively small amount and in no way form any rotation. Seed selection is rarely practised and the crops grown are often unproductive and unsuited to the conditions.

Planting is done by broadcasting the seed in front of the plough and subsequent cultivation is of a sketchy nature and generally too long delayed. This results in very patchy stands, poor early growth, due to the undecomposed material ploughed in, and enormous weed competition. Witchweed is prevalent and in general nothing is done to reduce its effect. With falling yields the tendency is to plough up more land and this still further decreases the attention which can be given to the crops.

The Swazi owns considerable herds of cattle in relation to the extent of his cropping area, and the system of night-kraaling of cattle results in the accumulation of stocks of kraal manure. In the past little of this was returned to the land and the prejudice against its use is presumably due to the ill effects following very heavy applications in the dry areas. Propaganda based on the results achieved with small applications will lead to more judicious and general use of the ample supplies available.

Some ten years ago cotton was introduced to the Swazi as part of a policy of improving the traditional methods by propaganda and demonstration. In addition to its value as a cash crop, cotton has amply shown its drought-resistance and its capacity for cropping under soil conditions where maize would fail. It is not affected by witchweed and would form a useful crop in a rotation. The value of a " new " crop—as cotton is to the Swazi—can be considerable in influencing the traditional farming practices. The older crops are hedged around by tribal rites and customs and change is difficult, but with a crop new to the people there is a tendency to adopt not only the crop but also the agricultural practices brought with it. This change is likely to react on the general system and standards. Encouraging results, even if on a small scale, followed the introduction of cotton, but the development was checked in the past few years by the demand for increased food production. The crop is suited to the area, but it has to compete with other sources of income from employment. Money wages are on a higher scale than in other African Colonies where cotton is grown, and the extent of production will depend on the prices obtained.

It will be apparent that any attempt to introduce cotton into the primitive agriculture of the Swazi must be part of a wider policy of general agricultural improvement. For this reason the work of the Corporation's Stations has been devoted to improving the food crops of the country and to problems of soil treatment and manuring. Improved methods are demonstrated to the natives in different parts of the country and there is some evidence that improvement is being made. Big increases in yield have followed the use of better seed and the use of kraal manure and better cultivation practices, and this fact holds out encouragement for the future. However, these cases are all too rare, and a much more intensified campaign of education and demonstration is needed, both in improving production and in combating erosion. A large Land Settlement Scheme has been started and the improvements which should follow in these individual holdings under supervision and control will affect the position in the Native Reserves.

PROGRESS REPORTS FOR THE SEASON 1943-44

Introduction.

At the beginning of the season the Government Farm at Bremersdorp, on which the Experiment Station is situated, was placed under the control of the writer with the object of developing it as a general agricultural experiment station. Much of the cultivated land was in a low state of fertility and infested with witchweed. Improvement has been started along the lines of green manuring, witchweed control, and the establishment of grass leys.

With some modifications, due to shortage of suitable land, the proposed experimental programme was carried out and progress was satisfactory. The main work continued on the lines of soil treatment and fertility, while selection work and strain tests were conducted on cotton and cereals.

In general the season was favourable as early spring rains followed exceptionally high winter falls, and conditions for ploughing and planting were good. In some areas rainfall was low in November and December, and this reduced the yields of early-planted maize. Rainfall was high during the next two months and then petered out coincident with the onset of cooler weather. Red bollworm caused some loss of crop in the early part of the season and there was some further loss by bacterial disease and by stainer later. Stalk borer was prevalent in maize and the late plantings were more or less seriously affected by Streak.

Very little commercial cotton was grown, though a few native growers continued with the crop and some encouraging yields—up to 800 lb. seed cotton per acre—were reaped.

BREMERSDORP STATION.

Meteorology.

The rainfall was high—42 inches from September to April—and just over half this total fell in January and February. Planting conditions were good and all the cotton and the main maize crops were in by the end of October. Crops established well and the high rainfall was favourable to maize. January and February were wet and cloudy and unfavourable to cotton, which made big, sappy growth. Red bollworm infestation was fairly heavy and there was some increase of bacterial disease in the wet conditions. Stainer was early in the crop and bred up rapidly, and cotton prospects were unpromising. March and April were dry and the crop opened fairly well, though the late crop of bolls never matured owing to the early drop in temperature and to stainer. In the circumstances the average yield of 900 lb. of seed cotton per acre was satisfactory. This Station represents the upper limit of cotton-growing in the country—at least as far as the present strains are concerned—and is not typical of the potential cotton-growing areas. Excellent yields are sometimes reaped, but only in the so-called "drought years" when the drier and hotter conditions approximate to those of the good seasons in the low veld. More often the conditions are too wet, accompanied by excessive cloudiness and with a short season due to early drop in temperatures.

Agriculture.

Fertilizer and Rotation Experiment.—This experiment, now in its sixth year, was planted to cotton. The rotation is alternate maize and cotton, except for one series with continuous maize. The treatments are compost (KM) and superphosphate (P) alone and in combination (KMP), and these are applied in alternate years, *i.e.*, to maize only, except for one series (KMP) which is applied annually.

As in previous seasons, treatment differences were pronounced. At two months samples showed substantial growth increases from all treatments, the largest increase following the annual application of KMP.

The yields followed the same trend as the growth observations. The annual application (KMP) yielded 900 lb. compared with 545 lb. from Nil, and the residual effects of KM and P were considerable.

The experiment so far has shown (*a*) the beneficial effect of cotton on following maize crops, and (*b*) the great effect of KM and P on the growth and yield of maize, and to a lesser extent of cotton.

Experiments are being started to investigate the effect of grass leys on soil structure and crop yields, and the above experiment will afford a useful comparison of the effects of continuous cropping.

Fertilizer Experiment (*B*).—This experiment is also on the loam soil and is of factorial design to test the effects of N, P and K, alone

and in combination. Direct applications were made in the preceding three years and this season residual effects were under consideration.

The layout was planted to maize which had good conditions and gave the good average yield of 2,700 lb. grain per acre.

The results showed significant increases, both in growth and in yield, following P. This effect of P, though still high, is less than in the three years of direct application, and the experiment will be continued to see how long the accumulated effect of phosphate will last.

Fertilizer Experiment (*C*).—A somewhat similar experiment to the above has been carried out on the light sandy soil, which is low in organic matter and poorer than the loam in all main plant nutrients. The results in the preceding years of direct application of N, P and K, were described in previous reports; this season maize was planted to ascertain residual effects.

Plant growth was poor compared with that on the loam in the experiment described above, and yields were correspondingly low, averaging 1,700 lb. grain per acre as against 2,700 lb.

As in the preceding years of direct fertilizer application, there was a significant increase in growth from the P series, with the double application (P2) higher than (P1).

The yield was poor for the Station and there were no significant differences between treatments.

The main features of these two experiments on the two soil types are :—

(1) The prime importance of phosphate on both the loam and sandy soil.

(2) Considerable effect of N in the form of nitrate of soda, but less pronounced than that of phosphate.

(3) Variable results from potash; there being no effect on maize crops, but significant yield increases in cotton.

Phosphate Trial.—Owing to the shortage of superphosphate a trial of various sources of P_2O_5 was carried out. These included superphosphate and finely-ground local rock phosphate in different amounts, alone and in mixtures.

The crop was not high, owing to witchweed infestation, but sufficient information was obtained to indicate the superiority of superphosphate in direct application. Residual effects will be investigated in the coming season and the trial with direct applications will be repeated.

Soil Restoration Experiment.—This experiment was laid down three years ago to test the effects of bush fallow and a range of resting crops in restoring soil fertility. The scope of the experiment and the

progress of the various crops have been given in previous reports. A note on the crops in the present year is given below.

Bush Fallow.—Analysis of the vegetative cover shows a further increase in total cover and in the number of grass species. Even in the third year the cover is mainly a mixture of annual weeds, but the proportion of grass cover has again increased and some of the better species are now appearing.

Rhodes Grass.—On this soil the performance of this grass is encouraging. In the first year the cover was fair, but by the second season there was a heavy growth which has remained equally good in the third year and yielded good hay crops. In view of the low fertility of the soil and of the fact that no fertilizers have been applied during the experiment the result is gratifying, and the grass shows distinct promise for soil resting in this area.

Pigeon Pea.—The crop grew well, both alone and with Rhodes grass, particularly in the first two seasons. In the third year there was a noticeable loss of stand after ratooning. The value of a suitable legume to grow with a grass cover is great, both from the soil fertility angle and for improving the herbage. Unfortunately suitable legumes are hard to come by, but work is being continued by collection of indigenous plants and by introduction.

The resting crops have now completed their course and the area will be ploughed up and planted to a test crop to observe the effects on growth and yield. Soil samples have been taken for soil structure determinations but, owing to the difficulty in obtaining equipment, the data are not yet available.

Green Manure and Witchweed Control.—The experiment proposed to compare the effects of sunnhemp and Sudan grass as green manure crops and their effect on witchweed had to be left over owing to lack of suitable land.

Cotton Strain Trial.

No cotton selection is done at this Station, work being confined to trials of strains in collaboration with the Barberton Station. The range of material included derivatives of U.4 and U.4×Cambodia lots, and a U.4×MU.8 cross.

Planting was completed early and stands were excellent. In the excessive rain and cloudiness in January and February the plants grew big and sappy, and losses by red bollworm increased. In the drier conditions which followed, the crop opened fairly well but the later crop of bolls came to nothing owing to the early drop in temperatures and to stainer.

The U.4 selections yielded highest and averaged 373 lb. lint per acre compared with 312 lb. from the others. It must be noted, however, that the loss of late crop affected the later Cambodia lots to a greater extent.

Rotation Crops.

Maize.—Selection work was continued on the Hickory King and White Flint types.

The past two seasons has seen a disquieting increase of Streak disease in late-planted maize, and to meet this a supply of resistant Peruvian × Hickory King strain was obtained from Barberton. This is being multiplied for issue for late plantings.

Kaffir Corn.—The successful P.127 and 74/T strains were grown.

Sunnhemp.—The crop is grown as a green manure on some European farms and makes satisfactory growth, but the conditions necessary for the production of good quality fibre have not been investigated. The experimental programme was as follows :—

(*a*) Plant density and manurial trial.—This experiment was laid out to test the effect on yield and quality of fibre of two seed rates—30 lb. and 60 lb. per acre—both on unfertilized land and on land receiving liberal dressings of compost and superphosphate. The experiment was duplicated at Croydon and, in addition, plots at the two planting rates were grown in various parts of the country.

(*b*) Trials were made of effect of cutting at different stages in the development of the crop.

(*c*) The effect of length of retting period and of different water temperatures is being investigated.

The agricultural side of the work was completed, but owing to the difficulty and delay in obtaining cement for the construction of tanks, the retting and scutching has not yet been possible.

The conditions were favourable for the crop and the yields of stalks compare well with figures available from other countries. Comments on the various treatment effects must await the obtaining of results from the fibre extraction, but some indications have emerged from the growing and handling of the crop. The cutting and general handling is laborious and costly, and economic production would depend on the replacement of hand labour by machinery. Sampling in a large number of crops has shown the big differences in uniformity of stand, giving a wide range of stem thickness which would interfere with the efficient working of the decorticator. It is obvious that very careful planting and the provision of a uniformly good seedbed are essential.

It is proposed to continue the experiments in the coming season.

Grass Introduction and Trials.

The development of this branch of the experimental work is overdue, but was not possible before owing to restricted land for experimental purposes and the need for work on the food crops of the

country. The European farming system is predominantly pastoral—at present mainly on a ranching basis—and with increased attention being paid to improvement in breed, it is necessary to find means to improve the nutritional status of the animals. The objects of the work are twofold :—(*a*) to supply the needs of stock under a more intensive system of production of beef and dairy products, and (*b*) to restore the productivity of arable land by the use of grass leys.

At one end of the scale are farmers concerned with the production of good quality feed for improved cattle during the dormant period in the veld. Provided returns are economic, high-yielding grasses will be grown and will receive a high quality treatment, to the ultimate benefit of the soil. At the other extreme is the land thrown out of cultivation on account of low productivity, due to overcropping without any return to the land, and to erosion, etc. The Soil Restoration Experiment described above shows—and this is amplified by observation—that land thrown out of cultivation goes back to grass slowly, depending on length of time under cultivation and soil fertility, and for some time a patchy cover of annual weeds and pioneer grass species is all that is obtained. Under these conditions the suitability of grass cover will be determined less by its productive capacity than by its ease of establishment and ability to stand weed competition.

To meet the varying requirements of the country the grasses under observation include types suitable for pasture, hay and ensilage. During the year the number was extended and now includes some 50 species, mainly in the following genera :—*Digitaria* (Finger grasses), *Setaria, Panicum, Echinochloa, Pennisetum, Chloris* and *Acroceras*. In addition to the nursery and introduction block a number have been planted out on field scale to provide information of yield of herbage. It is too early to assess the values of the grasses with any confidence, but several are very promising. Experiments are proposed for the coming season to compare a range of grasses from the point of view of soil improvement and of herbage productivity.

Legumes.—Annual legumes are grown for grain or as green manures, but there is a great need for perennial forms which can be grown with grasses. For dry land conditions the important legumes from other countries have so far not proved successful in South Africa. A collection of indigenous legumes is being made, including mainly species of *Crotalaria, Indigofera* and *Sesbania*.

CROYDON STATION.

This Station is situated in the Low Veld and is typical of much of the potential cotton-growing area. It is hotter and drier than Bremersdorp and is about 1,000 feet lower.

Meteorology.

The rainfall was high for this area—30 inches from September to June—but distribution was unfavourable. Of the total, 19 inches fell

during the months of January and February. Conditions for ploughing and planting were good and cotton and the main maize crops were sown during October. November and December had only 4 inches of rain and, though cotton came through the dry period well, the first-planted maize suffered. The position was saved by a good fall in early January and from then onwards there was ample moisture. Cotton suffered some loss by red bollworm, and stainer appeared early. In the dry period in March and April the crop opened well and yielded 1,200 lb. seed cotton per acre.

Agriculture.

Fertilizer experiments were continued both on maize and cotton.

Fertilizer Experiment (*A*).—This is the fourth season of the experiment, which is in a two-course rotation of cotton and maize. It is of factorial design, testing the effect of N, P and K alone and in combination. Fertilizers were applied in each of the three previous years and this season residual effects were under investigation.

Cotton was planted early and established well. The dry conditions of the early season were followed by high rainfall in January and February, and bollworm damage increased. The rains ceased early and the crop opened well and yielded 1,000 lb. per acre.

Yield differences between treatments were small, but there was a highly significant effect of P on early growth. In the three years of direct fertilizer application the outstanding increases in yield and plant growth came from the N and K series. It is proposed to run the trial for a further season under maize before analysing the complete results.

Fertilizer Experiment (*B*).—This is similar to the above, but with only two seasons of direct fertilizer application.

Maize was planted in mid-October and was always short of moisture, the crop receiving only 5 inches in 10 weeks after planting. The ample January rains came too late and the crop averaged only 1,250 lb. per acre.

As in the experiment with cotton, there was a significant growth increase in the early stages from P, but here again yield differences were insignificant.

Rotation and Manurial Experiment.—Previous work on this Station has shown the importance of all three main plant nutrients, and that large crop increases follow the application of kraal manure or compost in small amounts. These are deficient in phosphate and its addition still further increases yields. Under the existing system of night-kraaling of cattle, ample supplies of manure are available to the native cultivator and the use of phosphate is likely to spread.

The present experiment is designed to investigate :—

(1) The effect of small annual applications of compost and phosphate compared with larger amounts at longer intervals.

(2) The effect of green manuring in the rotation compared with applications of compost.

(3) The rotation effect of various crops.

The site was on land newly ploughed out of grass, and maize was planted at the end of October. Conditions were better than for the earlier-planted crops as the January rain arrived at the critical flowering period.

The crop made good growth, with the double application, KMP2, substantially highest.

In spite of the poor conditions in the early season, this crop was the best so far seen on the Station, averaging 2,800 lb. grain per acre. Yields followed the same trend as the figures for early plant growth, but the treatment differences were small. From previous experiments on the older cultivated fields on the Station, very considerable differences in yield would have been expected and the present big crop and small treatment differences are attributed to the effect of the long period under grass in the present experiment.

Samples for soil structure analysis have been taken and will be continued during the course of the experiment, to trace the effect of cropping from year to year.

Phosphate Trial.—The Bremersdorp experiment to compare the effects of different sources of P_2O_5 was duplicated here.

Maize was planted in mid-December. Conditions were good, but the crop was slightly affected by Streak and yielded 1,800 lb. per acre.

Both in final growth and in final yield the effect of superphosphate was significantly higher than that of finely ground rock phosphate. The experiment will be continued to ascertain residual effects.

Cotton.

A strain trial similar to that at Bremersdorp was planted at the end of October. The dry conditions of the early part of the season were followed by high rainfall in January and February, and there was some loss by red bollworm during this period. March was dry and flowering ceased, and the excellent crop of 1,300 lb. seed cotton was reaped from the short flowering season.

Yield differences between strains were small and, as at Bremersdorp, the short season did not favour the later Cambodia lots.

Rotation Crops.

Sunnhemp.—An experiment, similar to that at Bremersdorp, was planted to determine the effects of different plant densities and fertilizer treatments on the yield and quality of sunnhemp fibre.

The crop was planted in late November and made good growth in the good rainfall conditions in January and February. Retting and scutching of the crop has not yet been possible.

Cereals.—Strains of maize and kaffir corn were grown, and mass selected in the field, to provide seed for issue to growers.

Other crops grown to supply food and as sources of planting material were groundnuts, cassava and sweet potatoes.

PROGRAMME FOR THE SEASON 1944-45.

1. Variety trials of cotton strains from Barberton.

2. Selection work on maize will continue and variety trials over a range of planting dates will be conducted.

3. The investigations on sunnhemp as a fibre crop will be continued.

4. Work on soil treatment and manuring will continue :—

   (*a*) The combined fertilizer and rotation experiment at Bremersdorp will be planted to maize. In this, its seventh season, further information will be afforded on the rotational effect of cotton in addition to manurial effects.

   (*b*) The Croydon rotation and manurial experiment will enter its second season. This was planted on " new " ground and, in addition to the treatment effects, the effect of cropping on crumb structure will be followed.

   (*c*) The factorial fertilizer experiments at both Stations will continue for further observation of residual effects.

   (*d*) The phosphate trials will be continued to observe direct and residual effects.

   (*e*) An experiment is being laid down to determine the relative value of ploughing-in sunnhemp as a green manure, compared with the ploughing-in of the stubble only. Sudan grass is also included in the trial on account of its importance as a trap crop for witchweed.

   (*f*) The Soil Restoration Experiment will be ploughed and cropped. In addition to the treatment effects on the crop, the effect on soil structure will be followed.

5. Further experiments on the effects of resting crops are planned. These are :—(*a*) trial of a number of grasses over a fixed period of rest ; (*b*) trial of a small number of grasses with a range of resting periods ; (*c*) effect of method of planting of grasses, *e.g.*, broadcast, in rows from roots, etc., and also with a grass-legume mixture. The experiments are designed to provide information on productivity of herbage, effect on subsequent arable crops, and on soil structure.

6. The work on the introduction and trial of grasses and legumes will continue.

SOUTHERN RHODESIA

COTTON BREEDING STATION, GATOOMA. PROGRESS REPORT FOR THE SEASON 1943-44

BY

G. S. CAMERON.

Introduction.

A study of cotton-growing in Southern Rhodesia, over the past few years, makes it clear that considerable progress has been made in breeding a type of cotton suited to Rhodesian soil and climatic conditions. This is borne out by the fact that the last two seasons, which were considered to be too wet for cotton-growing, yielded crops which, it is true, were of low average yield, but good enough to maintain the crop's position in the economic scheme of the agriculture of the Colony. Now that cotton prices have been stabilised at a level which is more in keeping with other primary products, there is no need to fear a shortage of cotton for local requirements. There is little likelihood of there being cotton for export, at least not for several years to come, and not even then if there is going to be a repetition of pre-war slumps in cotton prices.

It has been made clear in former reports that the price factor is what determines whether cotton is an economic crop for Southern Rhodesia or not : Imperial preference for tobacco, export bounties for beef, and controlled prices for maize consumed in the country, in order to export it at a loss, all militated against extensive cotton-growing.

The other adverse factor has been the varying intensity of insect attacks, particularly bollworms and stainers, and, to a lesser degree, termites and locusts. Jassids completely wiped out a large number of crops in the early attempts at cotton-growing, but this particular pest has been overcome by the breeding-up of resistant strains. There remain the outstanding problems of how to deal with bollworms and stainers. These are the main difficulties to be solved now that prices can be dealt with locally. Although a complete solution to either or both bollworm and stainer pests is not within sight at present, there is, nevertheless, hope that the damage caused by them may be countered to a certain extent through the help of plant breeding, and by other means. In Southern Rhodesia, it is essential to breed for earliness so as to escape as far as possible the American bollworm which is ever-present, although it has been less in evidence over the past two seasons. The area of maize grown to cotton in Southern Rhodesia is in the ratio of about forty to one ; there is not, therefore, much chance of completely escaping American bollworm attacks as the adult moths leave the maize after it ceases to be attractive, and continue to lay their eggs on nearby cotton if, as usually happens, it

is in flower. Everything that helps to hasten the flowering period and get it over as early as possible renders cotton less liable to American bollworm attack. The unexplained lessening of the American bollworm over the past two seasons has been offset by an increase in Sudan bollworm population. Why this should be the case is not understood, and lack of staff precludes any possibility of investigating the situation.

The third serious insect pest, stainers, presents a problem that also remains to be solved, but there are indications that much of the damage which they cause may yet be overcome. Prentice's method of poisoning with sodium arsenite will be tried at Gatooma. One of the 9L families, 9L34, gives promise of harbouring fewer stainers than the other main family, 9L18. The latter has large fleshy leaves, while the former has smaller leaves, and the plants generally appear to give less shade. The past season was not a good one in which to show up the difference in attractiveness to, or harbourage of, stainers, between these two families, but this alleged difference will be investigated further next year, if there is any improvement in the staff position.

Meteorology.

The season was generally considered to be a very wet one, too wet for cotton, but the end results were an improvement on the previous wet season. As an indication of the seasonal variations experienced in Southern Rhodesia, the rainfalls for the last five years are shown hereunder.

1939–40	46·23 inches
1940–41	33·20 ,,
1941–42	21·79 ,,
1942–43	36·17 ,,
1943–44	39·64 ,,

These give a broad view of the rainfall conditions that may be expected, and the necessity of breeding cottons which will stand up to a drought one year, and, possibly, a flood the year following.

The total amount of rainfall, however, is only a part of the picture ; it is the incidence that counts with cotton. Early spring rains for planting, and an early cessation in the autumn enables the crop to ripen off well, and generally ensures good opening. It appears also that the climatic influence on insect populations affects the cotton crop. In the season under review light rains arrived early in October and planting rains by the middle of November. Thereafter they were continuous until early March when they stopped, with the exception of one day's rain towards the end of April. It was just the kind of season to promote large luscious growth with plenty of leaf and shade for insects, especially stainers. As a result of the type of season experienced it was expected that the cotton crops would contain a large proportion of discoloured cotton due to stainer damage and that there would be a high percentage of bad seed. Fortunately the reverse happened, and the crop turned out to be one of the cleanest on record.

This was in contrast to the previous season, and is explained by a reduction in the stainer population early in April, but no

explanation is offered as to why their numbers were reduced almost to vanishing point at a time of year when they are usually on the up grade.

Agriculture.

The average yield per acre of seed cotton throughout the Colony was 347 lb. per acre, compared with 307 lb. per acre the previous year, 1942–43, and 432 lb. per acre in 1941–42.

Maize yields on the Cotton Station were well above average, and came out at 16·9 bags per acre. The field which gave the lowest yield worked out at 12 bags per acre, and the highest at 24·4 bags per acre (a " bag " weighs 200 lb. maize nett).

Sunn hemp for seed, and grown as a green manure crop, did exceptionally well. Farmers and other visitors with agricultural experience remarked upon it being about the finest sunn hemp ever seen by them.

Soya beans, velvet beans for hay, and ground nuts all gave heavy crops. The latter yielded 28·8 bags per acre over 12 acres (a " bag " weighs 65 lb. nett, in the shell).

Fat Stock.

Out of 40 steers fattened and sold to the Cold Storage Commission, 31 graded " Imperial," the second highest grade. These gave an average dead weight of 637 lb. per carcase. The average dead weight for the 40 animals was 624 lb., which is considered to be very good for this type of beast.

Cotton Breeding and Genetics.

The 9L18 strain, which was issued two years ago as a stop-gap, again did much better in a wet season than was expected of it. Over two years in strain trials it has not equalled its successor 9L34. This season it has yielded better in two strain trials, significantly so in one of them ; it also has a higher ginning percentage which makes it difficult to justify its being superseded by 9L34. The latter has better lint and, generally, is an improved style of plant—more open, with smaller leaves, and the ripe bolls are more easily picked—an important point when the harvesting has to be done by paid and not very skilled labour.

Several very good re-selections from 9L34 are in process of being bulked up, and will be included in next season's yield trials. Their further retention will depend upon the behaviour of some of the families descended from the 1937 Station crosses against which they will be in competition.

No single-plant selections have been made since 1942, and attention has had to be confined to the study of progenies from that year's selections, and the gradual elimination of families descended from them.

Out of 52 small bulks from these families, 18 have been retained and 34 rejected. Of the retained families, six are from the 9L34 series, and seven from derivatives of the 1937 Station crosses. The latter are all heavy yielders, but their lint qualities fall short of the 9L34 standard. In addition, they persist in growing rank and coarse despite past attempts to select smaller-leaved, and more delicate-looking plants while keeping up to the required standard for jassid-resistance, earliness, and other desirable characters. Nevertheless, it is possible that too much attention has been paid to selecting small, hardy, and prolific plants. It may be better policy to permit the retention of large, coarser-looking types among re-selections and overcome the shade difficulties created as a result of their excessive foliage by pruning, or " topping " the plants at a time of year which has yet to be decided. It is fully realised that the practice of " topping " cotton plants has been tried in other parts of the world, and discarded. Conditions in Southern Rhodesia, however, may justify the practice, or at least condone an attempt to find out whether it may not succeed. The top part of the plant, which would be removed, flowers too late in the season to produce a crop of sound bolls which would open before the advent of the cold weather. Its removal, therefore, would be no loss, and the amount of strong sunlight that would penetrate to the middle of the plant should make it less attractive to stainers, and other shade-loving insects. In this connection it is proposed to carry out replicated trials in 1945 to find out the effect of topping on the yield of the plants, and whether there is any reduction in the amount of staining.

Thanks to Mr. Parnell, the following crosses, ex Barberton, were made available for observation.

A. 150	5143 × Cambodia
A. 250	5143 × Cambodia
A. 255	5143 × Cambodia
A. 262	5143 × Cambodia
A.2195	M.U.8 × 8161
A.2208	M.U.8 × 8161

Unfortunately the site chosen for them turned out to be very unfavourable for the kind of season. The land had only been broken in from virgin veld two years previously, and is not sufficiently well drained for an excessively wet season. The result was that the Barberton crosses showed up badly.

With the exception of A.150, they tended to grow too big, and carried an excessive amount of foliage for Southern Rhodesian conditions. The majority of plants were very resistent to jassid, but a severe attack of Sudan bollworm drastically reduced their yields. Sufficient of the original seed was held back to permit a replanting in the ensuing season for further observation. A.150 looks the most promising, giving small sympodial branched plants with medium-sized leaves, and not too many of them. The bolls were also of medium size, opening very well and yielding remarkably good lint for the size of boll and style of plant. The writer estimated the lint to be $1\frac{3}{16}$" which was corroborated by the Baer Sorter giving a

similar effective length. A.262 gave the best lint, followed by A.255 and A.250. The lint from the M.U.8×8161 crosses was below the standard set for local requirements.

The season brought to light one seed character in cotton which it is thought is frequently overlooked, namely, the variation in germination between strains and between their sub-strains. For some reason not understood the strain trials and increase plots germinated most erratically. Laboratory tests showed up varying differences between the percentage germination of strains.

Germination tests on moist cotton wool in petri dishes also showed that some strains germinated much more rapidly than others, although the final results did not show a higher percentage germination. This may have a very important bearing on the stand of young seedlings obtained in a year when planting conditions are difficult. It is a point worth remembering, and it is hoped that it will be possible to devote time to investigating it further.

Another observation, for what it is worth, is that acid-delinted cotton seed, treated with "Agrosan" dust, did not germinate any better than similar seed not treated with "Agrosan," when tested on moist cotton wool in petri dishes. On the other hand, the "Agrosan"-treated seeds remained clean and healthy-looking throughout the test, while a large proportion of the untreated seeds went mouldy.

Strain Trials.—Two strain trials were carried out between derivatives of the Station crosses, the strains 9L18 and 9L34, now in commercial cultivation, and certain other "possibles" for further multiplication.

These show that the families derived from the crosses yield significantly better than anything else in the trials. The displacement of 7C/94/6 from "equal second" in the first trial to "equal sixth" in the second trial is due to an unfortunate oversight at the time of planting, whereby a certain amount of light seed or "floaters" was used to eke out the seed supply. Under existing conditions, this is liable to happen.

1944 Field B.A.

8 Strains. Rows of 100 Plants. Replicated 9 Times.

Strain.	*Equivalent Yield, lb. Seed Cotton per acre.*
7C/86/5	577
7C/15/3	522
7C/94/6	499
9L18	429
7L5DC 1/1/1	382
9L34	374
7L5DC 6/1/1	358
7L5DC 9/1	335
Significant Difference (P=·05)	49·8 lb. per acre

1944 Field C.B.

8 Strains. Rows of 100 Plants. Replicated 9 Times.

Strain.	*Equivalent Yield, lb. Seed Cotton per acre.*
7C/86/5	731
7C/15/3	669
9L18	592
9L34	554
7L5DC 6/1/1	530
7L5DC 1/1/1	499
7C/94/6	468
7L5DC 9/1	429

Significant Difference (P=·05) ... ... 57·3 lb. per acre

Entomology.

The heavy rains, combined with their continuity, interfered seriously with the collection of field records. The land remained too wet and soggy to permit of Native recorders going into the fields at the time of year when their work is most important, namely January to April inclusive. Such records as were obtained could only be used as indications of the trend of what was happening, but they cannot be accepted as being at all satisfactory.

Bollworms.—Eggs and larvæ of American bollworm were difficult to find even on unmarked maize plants. They were still more difficult to find on cotton.

Sudan Bollworm.—By April, when the recorders were able to get into the lands, it appeared that Sudan bollworm, both eggs and larvæ, were in evidence, but not to any great extent. The numbers of young bolls damaged at an earlier period made it clear, however, that attacks had been severe.

Stainers.—Reference has been made to the unusual behaviour of stainer populations in that they decreased in the early part of April, and only appeared again in numerical strength towards the end of the month. By this time *D. intermedius* was in the ascendant, with *D. fasciatus* and *D. superstitiosus* about equal, but numerically on a much lower level.

As already stated, there was very little stainer damage, and the cotton crop, although not a heavy one, opened well, was easily picked, and there was an unusually low proportion of stained and discoloured lint.

Jassids.—These appeared to be numerous, but did very little, if any, damage. Perhaps this is due to the fact that no highly susceptible strains were grown, and all the cottons under observation, and being multiplied, are very definitely resistant to jassid.

Aphis.—No serious attack throughout the season.

Termites.—Not noticeable because certain fields are no longer planted to cotton on account of their previous record of being badly infested.

Locusts.—For the fourth consecutive season no damage to cotton was reported.

Root Knot Nematode.—A certain amount of apprehension has been evinced in tobacco circles lest cotton-growing tends to encourage nematodes, and, as there is a desire to find suitable rotation crops with tobacco, Mr. R. W. Jack, of the Tobacco Research Station, Trelawney, has been investigating the susceptibility of 9L34 cotton to root knot nematode.

The following are extracts from private communications to the author.

1. Dated 26th August, 1943.

" The indications are that this variety (9L34) is highly-resistant to the nematode. Seventeen plants grown for over three months in very heavily infested soil, have failed to show any infestation, to which may be added two others lifted and examined after a shorter period of growth."

2. Dated 29th May, 1944.

" I have recently examined plants of your strain of cotton, 9L34, grown in infested soil during the past season.

" The seed was planted in four $\frac{1}{4}$-acre plots and yielded twelve hundred and thirty plants at maturity. These were examined individually and not a single case of infestation was found, although I brought the microscope to bear on any remotely suspicious swelling at the roots.

This does not necessarily imply complete immunity, which is rare, but in conjunction with the results of pot tests, already reported, I think it may be taken as demonstrating a very high degree of resistance, as the plots were known to be heavily infested.

" Data on the value of this strain of cotton in rotations on nematode-infested soil will be available next season when the plots with their controls are to be planted with tobacco."

The results of Mr. Jack's further investigations are awaited with interest, and acknowledgment is made of his courtesy in supplying the foregoing information.

Mycology.

Owing to the wet season there was a far amount of angular leaf spot, but no sign of Blackarm. There was a lot of boll-rot, which was secondary to earlier punctures by bollworms.

As reported in the 1939–40 Progress Report, there were a number of wilted patches, bearing defoliated plants, but carrying a normal crop of bolls which opened well. There was no noticeable difference in the quality of the lint from these plants.

Miscellaneous.

The establishment nearby of the spinning mills in Gatooma has added considerably to the usefulness of the Cotton Station. It has put the plant breeder into direct touch with the commercial broker, and with the spinner of his product. It is possible for all three to get together, and discuss the merits or otherwise of any particular strain before it goes into commercial production. The plant breeder is able to see for himself the effect immediately of " neppy," " wasty," and/or soft staple cotton. Whether such defects, when they occur, can be overcome by plant breeding remains to be seen. So far no untoward difficulties have been encountered in spinning Rhodesian cotton, either in the quality of the raw product or in regard to climatic conditions. Textile manufacturers appear to be well satisfied with the quality of the various yarns supplied to them, and the only criticisms received to date make favourable comment on the superiority of Rhodesian yarn in comparison with yarn obtained formerly from India and Japan.

Hand Loom Weaving.—At the request of the Government, the Rehabilitation Committee for Disabled Ex-Servicemen, and others, a certain amount of investigational work has been carried out in connection with hand loom weaving.

American and Swedish hand looms have been made at very moderate cost on the Cotton Station. It has been found advisable to import the reeds and heddles, but otherwise the looms can be made locally. Fortunately there are a number of hand loom weavers in the Colony, both professionals and highly-skilled amateurs, and the range of fabrics woven by them has to be seen to be appreciated. Southern Rhodesia being a small country lends itself readily to the development of this craft, which is not likely to be affected by the advent of the power loom, now or in the future.

Housing for African Farm Labour.—In recent years much attention has been given to the improvement of housing conditions for Native Africans. The problem is being tackled throughout the length and breadth of the Colony, but it bristles with difficulties, not the least of which is the Native himself, who, conservative by nature, is inclined to distrust attempts at " improvement " as considered by the Europeans.

This year it has been possible to erect a number of brick-built houses on the Cotton Station, and, although they are not yet considered ideal, they are a very definite advance on the type of dwelling formerly built, and preferred, by Natives. The roof is of the barrel type, made of cement asbestos, unsupported by woodwork, and therefore very cool, as well as fireproof. Contrasted with the Native type of grass-roofed hut, it is also rainproof and can be fumigated easily and quickly by internal fire. As anticipated, there was a certain amount of reluctance to occupy these houses, but once their advantages were realised, there arose a keen demand for them.

Summary and Conclusions.

The type of cotton grown in Southern Rhodesia is well suited to the vagaries of the climate. Stabilised prices, on a level with other agricultural produce, ensure a sufficient supply of cotton for local requirements.

For the second season in succession there was too much rain for the cotton crops in general, but the results were better than anticipated. There was less staining of cotton than usual, and the crop turned out to be one of the cleanest on record.

The new strain 9L34 has been put into commercial cultivation. It is considered to be a better type of plant than its predecessor 9L18, and it has better lint qualities. There is some doubt, however, as to whether or not it will prove to be a better yielder.

Other crops on the Cotton Station yielded exceptionally well; the fattening of steers for the Cold Storage Commission was also a marked success.

Cottons descended from the 1937 Gatooma crosses are yielding better than any others, but their lint is mostly coarser and shorter. Also, the plants grow too tall and rank according to existing ideas. There is some doubt as to whether these ideas are sound and may not be in need of modification.

Barberton crosses grown in observation lines did not get a fair chance owing to poor soil conditions, and severe attack by Sudan bollworm. Some, however, produced lint of very good staple and character.

Owing to the season being so wet it was not possible to obtain crop records during the growing period. For the same reason data on insect populations were unobtainable.

Acknowledgment is made of investigations carried out on the Tobacco Research Station, by Mr. R. W. Jack, on root knot nematode susceptibility of 9L34 cotton.

Reference is made to the advantage of having the spinning mills in close proximity to where the cotton is bred. Hand loom weaving, and the construction of an improved type of house for African Natives are mentioned.

PROGRAMME FOR 1944-45.

Multiplication and further observation of families held in reserve for possible future issue on a commercial scale.

Small bulks of the above grown separately for selfing.

A main yield trial between the leading sub-strains from derivatives of 9L34, and the 1937 crosses. Yield trials of sub-strains (*a*) from 9L34, and (*b*) from Station crosses, and parallel trials of them (*a'*) topped and (*b'*) not topped, together with an attempt at analysing the amount of staining in the two treatments for purposes of comparison.

It is hoped that a trial will be carried out of Prentice's method of stainer poisoning, but this will depend on the nature of the season.

ANGLO-EGYPTIAN SUDAN.

PROGRESS REPORT OF THE PLANT BREEDING STATIONS, SEASON 1943-1944

BY

R. R. ANSON, R. L. KNIGHT AND S. H. EVELYN.

INTRODUCTION.

In order to present this season's Report in the form required under the Corporation's new instructions, Part I has been written in three sections. Section I deals with the agricultural background of, and the work that is being done for, the Egyptian-type crop ; Section II deals similarly with the American-type crop ; and Section III covers crops other than cotton. This arrangement was felt to be more suitable than the division of the Report under the headings of the three Stations, Medani, Kadugli and Shambat, because Shambat Station has no individual agricultural background, the work of this Station being ancillary to that of the other two. Furthermore, Mr. Anson has worked equally with American cottons at Kadugli and Egyptians at Medani.

PART 1.

SECTION I.

EGYPTIAN TYPES.

In the Sudan, the acreage under Sakel types of cotton fluctuates between 280,000 and 295,000 annually. This total is made up of three distinct areas.

(1) The Gezira Plain and various Government and private pumping schemes in its vicinity grow some 230,000 feddans.*

(2) The Gash, which lies between Khartoum and the Red Sea on the Khor el Gash, normally cultivates 32,000 feddans.

(3) Tokar, in the delta of the river Baraka, by the Red Sea and about 80 miles from Port Sudan, yields a further 30,000 feddans.

THE GEZIRA PLAIN AND WHITE NILE PUMPING SCHEMES.

The Gezira contains 5 million feddans of practically flat land with just sufficient slope to render it admirably suitable for irrigation. It ranges from roughly 1,240 to 1,300 feet above sea level. The soil is a heavy, rather impermeable salty, alkaline clay, low in content of nitrogen and organic matter. When sown to cotton it responds to early application of nitrogenous manures, but not to potassium, phosphorus, and minor elements. The short summer rains, of which two-thirds fall during July and August, permit the growth of grasses and sorghum. The rains are followed by a long period of bare fallow during which the soil dries and becomes extensively cracked. Wind and rain carry surface material down these cracks, thus setting up a process of soil circulation which is confined to the top two to four feet

* 1 Feddan = 1·038 acres. 1 Kantar = 315 lb. seed cotton. 1 Rotl = 0·99 lb.

of soil. The rainfall averages 15·8 inches per annum and is well defined. Cotton is planted from mid-August onwards to early September. Cotton picking seldom begins before January and ends in April or early May.

The Gezira Scheme.—The Sudan Plantations Syndicate and Kassala Cotton Company are part and parcel of the Irrigation Scheme which was originated by the Syndicate and which now covers an irrigated area of 1 million feddans. The land controlled by these two large concerns extends alongside the Blue Nile for roughly 120 miles and measures 40 miles in width, narrowing at each end to 5 or 6 miles. The allotment of tenancies to cultivators and the management of the cultivations are entrusted to the Sudan Plantations Syndicate and the *Kassala Cotton Company, each of which employs a large European technical staff. The Scheme is worked on a tripartite partnership. The proceeds of the crop after ginning and marketing costs have been deducted are divided in the proportion of 20% to the Syndicate or Company, 40% to the Government and 40% to the cultivators; in this way the scheme contributes more than 25% of the entire revenue of the Sudan and produces some 200,000 bales of high quality cotton and 60,000 tons of dura (sorghum) annually. Recently, as a war measure, it grew 12,000 acres of wheat. The Sudan Plantations Syndicate, and Kassala Cotton Company have between them 21,000 tenants about 80% of whom are local inhabitants, 5% from Western Sudan, 3% Falata from Nigeria, and 9% from French Equatorial Africa, the remaining 3% is made up from other Arabs from different parts of the country. Pickers arrive from various parts of the Sudan and French Equatorial Africa for the picking season, which lasts from January to April.

In addition to the acreage controlled by these two large concerns, there are several other areas, here grouped under the heading "White Nile Pumping Schemes." These include:—

(i) *The White Nile Alternative Livelihood Schemes*, supervised by the Government and designed to cater for local inhabitants who, on account of the Jebel Aulia Dam having inundated their former holdings, have been obliged to leave them. These Schemes comprise Abdel Magid, Fatisa, Hashaba, Um Gerr and Wad Nimr, and they have a total cotton area of 14,000 feddans.

(ii) *Other White Nile Pumping Schemes* between them cultivate some 11,000 feddans of cotton of which 10,000 are privately owned and managed.

The Cotton Crop in the Gezira Plain and White Nile Pumping Schemes.—About 207,000 feddans of Sakel and X1730A are annually grown in the Gezira and watered by gravity flow from the Sennar dam. In the northern half of the Gezira, Sakel is grown and in the south X1730A. Cultivation is done by diesel plant operating cable tackle.

* The K.C.C. has a slightly different arrangement.

Sowing in the north starts about August 10th and is generally completed by the end of the month. In the centre and south sowing begins about five days later and carries on into early September. Thinning to 3 plants per hole is advocated three weeks from sowing, but in adverse weather conditions the date may be delayed two or three weeks. Most of the weeding is done by hand with the ordinary native hoe, but bull-drawn hoes are also used. Three or often more hoeings are required. Picking starts in mid-January and ends by mid-April, and the uprooting of the crop starts on May 1st. Cotton in the Gezira usually receives about 15 waterings though the number may vary from 12 to 18. The usual rotation in the Gezira is cotton, fallow, dura, fallow or lubia, fallow, cotton, fallow, fallow.

The Gash.

The Gash is the name given to the important cotton-growing scheme near Kassala in the delta of the Gash river which rises in the Abyssinian foothills. This scheme is administered by a Board of directors, with the Director of Agriculture as chairman, other members include the Governor of Kassala Province, the Director of Irrigation and the Director of Accounts, together with a secretary and the manager of the scheme.

The irrigated area is about 55,000 feddans, but this is completely dependent upon the size of the annual flood brought down by the Gash river which usually floods towards the end of June and runs for 100 days or so. The flood waters are controlled to a certain extent by a series of canals. From these canals, which follow the natural contours, others (*misgas*) radiate off to flood the area which is divided into 224 *hods*. Each *hods* equals 4,000 feddans or 25 *squares*. Each *square* equals 160 feddans, thus the total area of 224 *hods* equals 896,000 feddans. Each *square* of 160 feddans is subdivided into 16 lots of 10 feddans for the purpose of watering. Each lot of 10 feddans is called a *Gitta*.

The rainfall is about 16 inches per annum, but it unfortunately coincides with the flood. The rains cease in October and no further irrigation is given. Little cultivation is done; weeds grow prolifically and some difficulty is experienced in keeping them in check.

Cultural Methods.—The area to be cultivated is cleared of heavy tree growth, mostly Ushar (*Calotropis procera*) before watering and inter-misga banks made. It is then watered for periods varying from 7 to 30 days, sowing is done on the flat with a sowing stick, and spacing is roughly 1 metre by 1 metre. Rows are rarely straight, a fact which would make mechanical cultivation difficult. Levels vary considerably, thus causing areas to be unevenly watered in many instances, which means that only the effective well-watered area can be counted on to give an economical yield. All varieties of cotton grown in the Gash usually make much stronger growth, and have a more open but more monopodial habit than they do in the Gezira;

for this reason a much wider spacing is used with a concomitantly lower seed rate per feddan. The soil is composed of two types :—

(1) Light alluvial silt brought down by the flood (*Labad*).

(2) An alluvium of rich black clay (*Bardob*).

The Gash scheme, being relatively free from Blackarm disease, has for a number of years been used as a filter, as it were, through which is passed cotton selected and rogued at the Barakat Seed Farm ; in the Gash delta it is bulked up to commercial proportions and brought back again for planting in the Gezira as a commercial crop. In this way the new seed is generally fairly clean and uninfected with Blackarm, which in some seasons can be the cause of a serious loss of crop in the Gezira.

Types of Cotton.—As a rule two varieties, Domains Sakel and 1730A, are grown over equal areas but on separate canals with a wide area of fallow which permits isolation of roughly two miles between varieties. In the season under review, however, a further variety, namely BAR. N.T.2/41 (" Barsak "), a Blackarm-resistant strain developed at Shambat substation, was grown on a plot of 1,000 feddans and well isolated. The Gash scheme is ideally placed for the bulking of increase areas of new introductions or new strains which leave the Seed Farm in the Gezira for further bulking. The only ways in which mixing of types is possible are :—(1) Carelessness in labelling at buying centres, which would be most unlikely to happen when dealing with only one type. (2) Carelessness at railhead, *e.g.*, bags of 1730A being stacked with Domains Sakel. (3) Volunteer plants of either type occurring amongst the other, which is practically impossible under present conditions as the area growing cotton is fallowed for two years before it is planted with cotton again, and, as this cotton area is not watered for two years, it seems unlikely that any volunteer plants could persist over that period until cotton is again grown in the land. (4) Failure to clean the gins thoroughly and mixing of seed cotton at the factories at Port Sudan.

Pests.—Practically all known pests usually found in the Sudan are found in the Gash crop, but thrips, leaf curl and asal (a stickiness of leaf caused by aphis) generally do most damage to it, although in some seasons pink bollworm has been the cause of considerable loss of crop.

Tokar.

The Tokar Delta lies about 55 miles south-east of Suakin on the Red Sea Coast and has an area of some 386,000 feddans. The soil is a silt deposit brought down by the river Baraka from the Eritrean Hills. " As the river spreads over the plain its rate of flow is slowed down, and the large amounts of silt carried in suspension are deposited. The coarser particles are thrown down first and the southernmost areas are therefore largely composed of sandy soil and are mainly reserved for grain crops, chiefly *Pennisetum typhoideum* Rich. (*dukhn*),

and growing of cotton is not encouraged in this region. Except for the southerly portion, the soil consists of fine silt laid down by the river and this silt is of high fertility where weathered. The underlying soil often varies. On the fringes of the delta it may be sand or gravel. Near the sea-coast the land may be too impregnated with salt to allow growth. In other places alternating layers of sand and silt are found. Frequently the old silt deposited is covered by dunes (*debbas*) of varying size, which preclude cultivation except in pockets into which the flood has penetrated."

" All these types of land are potentially cultivable, for the thin soil may have fresh overlays of silt deposited on them, thereby increasing the depth of the fertile profile. The debbas consist chiefly of weathered silt, and they may be swept away by flood or wind action and deposited elsewhere. Even the salty land improves with the leaching action of frequent flooding and the new silt deposited, and land which was regarded as useless, owing to its saltiness, in 1921, was growing the best cotton two years later."

The flood extends from mid-July to about mid-September, during which period the Baraka comes down in a series of flushes, often drying up completely between flushes.

The Cotton Crop in Tokar Delta.—The cotton area is very variable from season to season, being dependent on the quantity and nature of the flood. In the period 1908–1938, the area sown with cotton has ranged from some 21,000 feddans (1908 and 1935) to 116,514 feddans (1920). Not all the area sown in any one season grows " effective " cotton and the effective cotton areas ranged in the same period from 10,961 feddans (1908) to 70,000 feddans (1920). The variety X1730A is grown in preference to Sakel because the former shows marked resistance to leaf curl under Tokar conditions. Until the 1930–31 season this disease had been absent, or negligible, at Tokar, but from then onwards leaf curl became increasingly severe, and in 1933–34 some 50% of the crop was lost on this account. Up till this time Sakel had been grown ; in 1935–6 X1530 was substituted as the main crop because of its leaf curl-resistance, and this was replaced by its congeners X1730 and, later, X1730A.

Sowing is done, following the flood, as soon as the land has dried sufficiently (usually September) but late flushes sometimes wash away areas of young cotton, necessitating re-sowing. About five seeds per hole are sown and the spacing is irregular, though it approximates to 1m. × 1m. Spacing depends very largely on the weed growth and on whether the land was lightly or heavily flooded. Very dirty land or lightly watered areas may be sown as closely as 25 × 50 cms. Cotton is sown by lifting a slab of the newly deposited silt, which is sterile, to expose the fertile silt below. A hole is made in this by the sowing stick (*seluka*) and the seeds thrown in and buried. Thinning to 3 plants per hole is done at three to four weeks. On clean, heavily

flooded, land little cleaning is required ; on weedy areas it is often limited to a circle round each plant. Picking starts about mid-December and goes on till mid-May or early June.

Plant Breeding in Egyptian Types.—The main problems facing the plant breeder in the Sudan so far as Egyptian cotton is concerned are listed below in the approximate order of their importance :— (1) Blackarm (*B. malvacearum*) resistance. (2) Early maturity. (3) Improving staple regularity, yields, and quality. (4) Jassid resistance. (5) Leaf curl resistance. (6) Bollworm resistance. (7) Termites and fleabeetle, which can also cause considerable damage, but there appears to be no likelihood of any control by plant breeding methods.

1. *Blackarm Resistance.*

Blackarm disease still causes considerable direct damage, particularly in the Southern and Central Gezira, in years when the climate is suitable for the rapid spread of the bacterium. In certain seasons there is a moderate direct loss, due to Blackarm, in the Gash also, but Tokar, because of its climate, is almost entirely free of the disease.

At present, Blackarm is controlled in the Gezira by seed disinfection (with Abavit B), delayed sowing, root pulling and burning at the end of crop, and field sanitation by sweeping up and burning debris—all costly and laborious measures. Because of the degree of control secured by these measures, the indirect effects of the disease are, in most seasons, more deleterious than the direct crop loss.

In the Gezira the most important indirect effect is brought about by delaying the sowing date in order to avoid the worst Blackarm period. It is widely held that this late planting considerably reduces the average grade of the crop so that the financial loss due to this form of control is considerable. A second indirect effect of Blackarm is to tie the Southern Gezira firmly to the production of X1730A (which has the capacity of growing away from the disease), even were it to prove for other reasons desirable to grow Sakel in the South.

In the Gash the indirect effect of Blackarm is also considerable, for, owing to the danger of primary infection if Gezira-produced seed is used for sowing in the Gezira, the Gash is being used as a seed farm. Gezira seed is sent to the Gash where it is grown for one season and then returned to the Gezira. This has the effect of " filtering out " much of the Blackarm, but it means that the Gash Board is tied to growing only such varieties as are required by the Gezira authorities.

Clearly, even apart from the direct effect of this disease, the production of Blackarm-resistant Egyptian types is of considerable importance. Details of the work of producing such varieties are given below :—

(*a*) *Blackarm-Resistant X1730.*—Seventh backcross material of X1730 type, containing the American Upland resistance gene $\mathbf{B_2}$, was on test in five variety trials in the Gezira this season under the number BAR.1730L. In two tests at Turabi in the northern Gezira it yielded the same as X1730A. Blackarm on these two sites was negligible. At all of the other three tests, Hag Abdulla, Barakat and the Gezira Research Farm, it out-yielded X1730A, owing presumably to the greater incidence of Blackarm in these districts. Spinning results from these trials are not yet to hand, but the last two seasons' figures from Shirley Institute and from Giza show only minor fluctuating differences between BAR.1730L and X1730A such as would be expected from sampling errors.

In view of these results, BAR.1730L will go to an isolated increase area in the Gezira next season with a nucleus of 9th backcross material also homozygous for $\mathbf{B_2}$.

Enough seed was produced from out-of-season breeding plots to sow a small propagation plot of X1730 type containing the *G. punctatum* Blackarm-resistance factor $\mathbf{B_3}$ in addition to the American factor $\mathbf{B_2}$. This material is extremely resistant.

(*b*) *Blackarm - Resistant N.T.2.*— About 1,000 feddans of Blackarm-resistant N.T.2 were grown this season at Metateb in the Gash. This was seventh backcross material containing $\mathbf{B_2}$. A 20-feddan area of this was heavily rogued to provide seed for a further 700–1,000 feddans in the Gash next season, and this will contain a nucleus of 9th backcross origin, seed for which was produced at Shambat this season, and a smaller nucleus of 10th backcross material from the out-of-season plots. The remaining seed will be used to sow a whole block (about 6,500 feddans) in the Gezira in 1944–45.

During the winter of 1943–44 seed was produced for sowing bulk propagation plots next season of N.T.2 type containing both resistance factors, $\mathbf{B_2}$ and $\mathbf{B_3}$.

There has been some misunderstanding as to the objective in releasing Blackarm-resistant N.T.2 types. N.T.2 is resistant to leaf curl and of better spinning quality than X1730A. Now that Blackarm-resistance has been added to it, this type is put forward as a possible alternative to X1730A. It is *not* now suggested as a replacement for Domains Sakel because although N.T.2 out-yields Sakel its quality is inferior.

It was considered that selection within the resistant material (both X1730 and N.T.2) would be necessary to obtain best results and with this object a large number of single-plant selections were made in the 1942–43 season from bulk sowings of resistant X1730A and N.T.2, and approximately the best 50 selections of each variety grown as single progeny rows this season for analysis and further selection. In the resistant X1730 group the selfed seed of 10 of these selections is being bulked to form a nucleus multiplication plot in the

Sudan Plantations Syndicate's area and the seven best selections will be grown as separate bulks at the Gezira Research Farm for further observation and analysis, and the lint of these will be sent for hair and spinning tests ; similarly in the resistant N.T.2 group half of the selfed seed of 11 progeny row selections will be bulked to form a nucleus multiplication plot in the Sudan Plantations Syndicate's area, and the remaining selfed seed of these will be grown as separate bulks at the Gezira Research Farm and their lint tested for hair and spinning characters.

(*c*) *Blackarm-Resistant Domains Sakel.*—Mr. Evelyn, working at the Gezira Research Farm, has been producing a pure bulk of selected Domains Sakel. His stock has been used at Shambat in a crossing programme designed to transfer the Blackarm-resistance factors $\mathbf{B}_1$, $\mathbf{B}_2$ and $\mathbf{B}_3$ from N.T.2 backcross types to Domains Sakel. F_1s of these crosses were sown in the breeding plots, first backcrosses were raised out-of-season and seed of second backcross type has been produced for sowing in 1944–45.

(*d*) *Transference of Blackarm immunity from* G. Sanguineum (*n=13*)* *to Egyptian* (*n=26*) *types.*—A small third backcross progeny was raised in winter of 1943–44 and bolls containing fourth backcross seed have been obtained, but have not yet opened. Sterility in the second backcross material was not as pronounced as in the earlier generations, but was still present in the third backcross progeny. It is expected that the fourth backcross will be more or less fully fertile. Results to date indicate that a single resistance factor is being transferred, but it is not yet known whether this is fully, or only partly, dominant. In the heterozygous state it does not confer immunity on Sakel, but only resistance ; it remains to be seen whether immune types appear when selfing becomes possible.

(*e*) *Flagging Blackarm-resistant X1730 and N.T.2 strains with the arboreum gene for red flowers and leaves.*—The *arboreum* gene for red flowers and leaves has been transferred to Blackarm-resistant X1730 and N.T.2 types from Harland's RU.4 as a means of "marking" these strains to make it easier to keep them pure.

Seventh backcross material of X1730 types was included in the standard variety test at the Gezira Research Farm this season. In plant habit, yield, ginning outturn, etc., it was typical X1730. Spinning tests from this variety trial are not yet to hand, but Shirley Institute figures for the previous season showed it to have a hair weight per cm. of 166 compared with 156 for N.T.2/39, 158 for X1730A, and 144 for Domains Sakel. It remains to be seen whether this high hair weight is inherent in all material carrying the Asiatic gene R_2^{RS} and spinning reports on ninth backcross N.T.2 and X1730 material from the micro-tests at the Research Farm will probably elucidate this point.

* *G. arboreum* v. *neglectum* f. *bengalensis* H. & G.

2. *Early Maturity.*

Early maturity would be of considerable value in all three of the Egyptian cotton areas in the Sudan—the Gezira, the Gash and Tokar. In the Gezira earlier varieties could save at least one complete irrigation, possibly two, whereas in the Gash and Tokar earliness would mean avoidance of the end period of the season, when water is short in the soil. Also, in the Gezira, it is widely held that greater earliness would give a higher proportion of grade 1 cotton. Finally, in all three areas an earlier crop would mean less bollworm in the end period and a longer dead season for all diseases and pests.

Despite the importance of this problem, no work has so far been done on it, since it was necessary first to analyse the available material to determine what degree of genetic variability was present and so whether there was a fair chance of selection having advantageous effects. This was done this season and, as a result, selected strains of Domains Sakel, Blackarm-resistant X1730 and of Blackarm-resistant N.T.2 are available for observations on node number and dates of last picking.

3. *Improving staple regularity, yields and quality.*

Although the Domains Sakel of the Sudan bears a high reputation for its staple quality, it is considered that there is still room for improvement not only in quality but also regularity, and the results this season hold out much promise in attaining all these goals.

No selections in the past from X1730 and its descendants have shown improvement in yield or quality over X1730A. The Blackarm-resistant X1730L, however, shows much promise in this direction and this season's results were very encouraging.

The N.T.2 strains, both susceptible and resistant to Blackarm disease, although high-yielding, are handicapped by their high hair weight. High variation in lint quality was observed in this season's progenies of resistant N.T.2/41, and it seems likely that this fault will soon be corrected.

All the important varieties and selections, including the latest Blackarm-resistant strains, were grown in a randomized progeny layout this season and analysed for all major characters. Two major facts emerged from this test (1) that variation, in a fairly high degree, exists within all varieties, and (2) that much of this variation is in the right direction.

4. *Jassid Resistance.*

Jassid damage can be extremely severe in the Northern Gezira and quite serious in the Gash.

The transference of the Tanguis gene **H**, governing leaf hairiness, to X1730, N.T.2 and Domains Sakel, was continued. In the former two varieties the crossing was switched to Blackarm-resistant strains

since the lint of the resistant types has proved satisfactory. It is not yet known whether the gene **H** can be transferred without affecting lint quality, but small propagation plots of late backcross material were grown to provide seed for a test of jassid-resistance and of lint quality in the Gezira next season.

In addition, hairy strains of X1530 origin are being re-selected and tested in the breeding plots and at outstations. These strains have already shown a degree of resistance, but generally possess short coarse lint which is gradually being bred away from.

5. *Leaf Curl Resistance.*

Leaf curl disease is still a potential danger over all the Exgyptian cotton areas in the Sudan though suitable control measures have prevented a repetition of the ravages it caused some ten or twelve years ago. These measures consist in (i) root pulling at the end of each season, (ii) growing X1730A in the Southern Gezira, in Tokar and in part of the Gash, (iii) attempting to enforce a dead season for bamia (*Hibiscus esculentus*), (iv) encouraging the growth of leaf curl-resistant Momtaza bamia in preference to the local type.

The work on leaf curl has already been described in some detail in former reports and so only the bare outline of this season's results is given, as it is hoped to write a full account for publication shortly. Twelve strains were tested against commercial Domains Sakel, including the latest of the Blackarm-resistant N.T.2 and X1730 strains. Like their parents these were highly resistant to leaf curl and will not be continued in future tests. Massey's Domains Sakel selected from the previous season showed very high resistance, 6% at end of March as against the control at 48%. Selected Domains Sakel from the previous season also showed significant resistance—34% as against the control at 48% at the end of March. Two improvements to the testing technique were introduced this season : (1) the measurement of plant height at maturity as an indication of fertility, to determine whether fertility influenced incidence of the disease. The results showed no correlation between plant height and disease incidence. (2) The cutting back of the experiment at the end of March and a further count of disease incidence on the cut back material at the end of April. The increase in incidence, aided by the cutting back, was fairly constant for all resistant progenies, the control and the spreaders ; and all resistant progenies again showed significant resistance over the control.

Next season only resistant M.S.D.S. and resistant Domains Sakel selections will be tested against commercial Domains Sakel. It is quite clear that selection is having its effect and this is particularly noticeable in M.S.D.S. and Domains Sakel—both of which were formerly considered to be fully susceptible.

6. *Bollworm Resistance.*

As stated in last season's report, *G. Thurberi* appears to be immune to pink bollworm at Shambat. Several F_1 plants of *Thurberi*

(n=13)×Sakel (n=26) composition were raised and backcrossing to Sakel was attempted without success. To facilitate crossing, several F_1 plants were treated with colchicine to produce a fertile (2n=78) type. The results appeared promising, but unfortunately the treated plants, which had been cut back to produce the vigorous growth requisite for colchicine treatment, all went down with a severe leaf curl attack and no bolls have as yet been produced. The experiment will be repeated next season.

G. armourianum also appears to be markedly resistant to bollworm and here greater success has been achieved. As with *Thurberi*, the F_1 of *armourianum*×Sakel is sterile but a presumed hexaploid (2n=78) has been obtained which sets fertile seed relatively freely and it is proposed to utilise this in backcrossing to Sakel next season. For convenience of reference this hexaploid has been called *G. "armadense"* since it is, in effect, a true species.

Section II.

American Types.

The total area of American cotton grown in the Sudan has generally had to be estimated from seed issues and is, therefore, largely guesswork. Before the war the average acreage was in the neighbourhood of 155,000 but showed considerable variation. This area was made up of some 115,000 acres in Kordofan, about 8,000 in Upper Nile, 22,000 in Equatoria, and roughly 11,000 on Government pumping schemes and private estates in Northern Province. Largely as a result of the war, very little cotton is now grown in Upper Nile and, except for the Sudan Plantations Syndicate's crop of some 5,000 acres at Zeidab, no irrigated American cotton is grown, whilst, in general, the area of cotton in all the rain areas has decreased considerably. American cotton is now grown as a commercial crop in only three areas: the Nuba Mountains district of Kordofan, the Maridi-Yambio area of Equatoria and the Sudan Plantations' estate at Zeidab in the Northern Province.

Kordofan Province.

Introductory Statement.

General Background of Agricultural Circumstances.—Kordofan, with its varied physical features and soil types, is the third largest Province in the Sudan. It is bounded in the north by the Libyan Desert, in the south by Equatoria and Upper Nile Provinces, in the east by the Gezira and in the west by Darfur. It is roughly 147,100 square miles in area and has a population of 1,222,729. The Province is divided into six districts and the Nuba Mountains (the area with which this report is concerned) are spread over two of these districts, namely, Western Jebels and Eastern Jebels. In these two districts the total area surveyed agriculturally is 24,500 square miles. The estimated area of land considered suitable for cultivation is 9½ million

feddans and the estimated area under cultivation is 600,000 feddans. The adult male population is about 97,000, of which 61,000 are Nuba and 36,000 non-Nuba (mostly Arabs).

The country consists of clumps of granitic hills rising steeply from a plain of detritus. The hills consist of bare rock and thin reddish gritty soil formerly carefully terraced by the Nuba. Now that slave raiding has stopped they prefer the easier cultivation of the plain and the terraces are being neglected with consequent danger of soil erosion and impoverishment of water supplies. Near the hill foot a brown faintly alkaline but salt-free fertile soil accumulates. Moderate water supplies commonly exist near the hill foot and plentiful well water is found in valleys of the brown soil between adjacent hills. These soils have been deposited from running water and consist of bedded material ranging from sand to clay. They are unstable, since, during the rains, they are traversed by meandering streams, but with reasonable attention soil erosion can be kept in check and is not of great consequence where the deposit is deep. At the hill foot, however, sheet erosion has occurred in places leaving a relatively hard, feebly permeable and intractable residue. As the valleys broaden out to the plain the deposit of detritus becomes deeper and contains more clay, the colour changes from brown to gray, and water supply, excessive during the rains, is entirely lacking thereafter except for rare wells or where ponds have been dug.

There are corresponding changes in the vegetation. Where the Nuba Mountains meet the flat sand dune country of Northern Kordofan the summer rains amount to about 24 inches, the rest of the year being dry. The low land carries short grass and thorn scrub, mainly *Acacia Nubica* and *A Mellifera* with *Balanites Aegyptiaca* in the valleys and *Terminalia Brownei* as a common small tree. Further to the south the rainfall increases to about 32 inches. Here *Boswellia papyrifera, Combretum undulatum* and *Anogeissus Schimperi* are conspicuous on the hills, together with the grotesque *Adansonia digitata; Borassus flabellifer* and *Hyphaene thebaica* accompany *Balanites Aegyptiaca* in the valleys, and the plains carry mainly tall grass with dense stands of the red-stemmed *Acacia Seyal* in the shallow depressions which receive rain run off from higher land.

Most suitable for cultivation are the brown moderately heavy clays found in valleys or near the hill foot in the southern part of the area. The grey, alkaline but still salt-free, heavy clays of the tall-grass-*Acacia Seyal* plain also give satisfactory crops, but are not easy of access during the rains and, owing to lack of drinking water, are difficult to harvest during the dry season.

The Nuba Mountains are favourably situated for economic development since they lie in an angle between the railway and the White Nile over two main transport routes. In this development attention should be paid to soil conservation on and near the hills,

and cultivation should form a ring around these protected areas and gradually extend out into the plains as water supplies and transport facilities improve.

The rainy season is well defined and typically lasts from June to October inclusive. Much of the rain falls during heavy thunderstorms accompanied by strong wind—a combination liable to cause serious soil erosion. The average maximum and minimum temperatures during the five months of the rainy season at Kadugli are 94·5°F. and 70·5°F. respectively. In November rain ceases and nights begin to cool down but day temperatures remain high. December, January and February are generally cool and dry, with northerly winds prevailing; in March temperatures begin to rise and April and May are usually the hottest months.

Permanent Water Supply.—Well-water is generally plentiful in favourable situations near the hills, but scarce out in the plains where wells often have to be dug to a depth of 160 feet or more. This lack of water in the plains, where the best soils lie, is the most important factor limiting the increase of cultivation there. When rains have ceased, native cultivators are dependent on depressions dug in the ground which, at most, are capable of retaining water for 3 months. This water shortage makes earliness essential in cotton varieties selected for this area, since an early ripening crop clearly stands most chance of being completely harvested.

Health.—During the rains the Nuba Mountains are very unhealthy, outbreaks of cerebro-spinal meningitis, malaria and blackwater fever are ever present; between them they take a heavy toll of the population. In addition, epidemics of relapsing fever and yellow fever are not uncommon. During the yellow fever epidemic of 1940 there were approximately 20,000 cases, 2,000 of them fatal. Finally, diseases such as leprosy, tuberculosis, dysentery, Kala-azar rabies and undulant fever are all endemic.

The Cultivators.—Most of the cotton is grown by Arabs, the majority of whom are cattle owners rather than serious cultivators. They can be classed into two groups :—

(1) The semi-nomadic tribes who migrate with their flocks and herds each year leaving behind them a small remnant to cultivate food and cash crops for them on their return. These semi-nomads are made up of Messeria, Hawazma, Awlad Himeid and Humr tribes who, together would number approximately 16,000 adult males. They are generally poor cultivators. The migration of cattle commences in early June and they return in early November. The main object is to get the cattle away from areas where, during the rains, blood-sucking flies and other insects abound. They usually take their cattle to the drier sandy areas of Rahad and Um-Ruaba.

(2) The sedentary tribes which include the Kawahla and Kenana tribes, the Arab-Nuba half-castes of Talodi, El Liri and Kadugli, and the West Africans, in all numbering approximately 14,000 adult males. With the exception of the West Africans, who are very good cultivators, these people are also primarily cattle owners, some of whom send their flocks and herds away with those of the semi-nomads, others own the small stocky Nuba cattle. These cattle are very hardy and have tough skins which are almost impervious to biting flies, and they can live and thrive where most cattle would probably die.

The Nuba are by no means serious cotton growers; they are, however, a fascinating, unsophisticated people whose principal wants appear to be a string of beads, with which to decorate and clothe their bodies, a cup of beer made from dura, and dura bread with which to sustain them, and a rifle to provide them with an occasional meat course. At the present time cash crops do not interest them because there is little for them to buy with the cash. Many of these Nuba have joined the Army and with it they have travelled far. It is not unlikely, therefore, that money, and that which can be bought with it, may mean more to them when they settle down after the war.

Cultivators and Labour Supply.—About 80% of the cotton grown in the Nuba Mountains area is owned by the Arabs, Nuba-Arab half-castes, or by West Africans (of whom about 2,000 families have settled in the Nuba Mountains). Most of the picking is done by Nubas who come down from the Maro, Mesakeen and Katla hills. Conversely, roughly 75% of the grain crop, mostly dura (Sorghum), is produced by the Nuba. The average pre-war production of grain amounted to 714,000 ardebs (1 ardeb=336 rotls). Since the war the grain crop has been increased very considerably and, because of transport difficulties, the area under cotton has been reduced to less than one-quarter the normal production.'

Systems of Agriculture.—Like many other native agriculturalists in Africa the cultivators of the Nuba Mountains have no hard-and-fast system of rotation, but practise (particularly on clay soils) continuous cropping. When yields deteriorate, they rest the land for several years, allowing it to return to bush and become covered with a strong growth of grasses. On the Goz soils this practice becomes more difficult and unless the farmer exerts more ingenuity his land deteriorates rapidly. Many Nuba therefore adopt slightly better methods, and it is not uncommon to find legumes (mostly *Vigna* sp.) mixed with the dura crop. Mulching by leaving grass and weeds on the ground to rot after rough hoeing is sometimes practised; this adds humus and prevents erosion. Often after harvesting the heads, the dura stalks are left on the ground to rot and in some localities they are laid on the natural contours in order to prevent erosion. Most of the Nuba cultivators favour dry sowing, a practice which is a definite gamble but if, after the first rains have broken, there is no

dry spell before the wet season begins in earnest, this practice insures better yields because the crop is able to get every available drop of moisture.

Harig Cultivation.—A number of cultivators practise what is known as "harig" cultivation. This can only be done on fertile cotton soil plains where strong growing grasses such as *Brachiaria Obtusiflora, Hyparrhenia Rufa* and *Hyparrhenia Pseudocymbaria*, form a dense mass which, when dry, is suitable for burning and generating intense heat. The principal feature of this "harig" cultivation consists of allowing grass from the previous season to remain on the ground until such time as early rains have germinated a new crop underneath it, then, choosing suitable weather in order to insure a good burn, the old dry grass from the previous season is set on fire. This has the combined effect of killing off all new weed growth and, at the same time, cleaning the land and freeing it for a time from insect pests. Unfortunately it generally means a late sowing date which, with such a short season as the Nuba Mountains enjoy, is a disadvantage.

Ploughing, except on Government Stations, is never practised, partly because of rinderpest and the numerous blood-sucking insects (including tse-tse fly in some parts) which abound during the rains and make the life of all draft animals both miserable and short, and partly because deep cracks aerate the soils and thus make it less necessary. Most of the sowing is done by means of a long bamboo with a small iron hoe attached or by a hard wood stick with a flattened end; these sticks sometimes measure 10 feet in length. Many Arabs and others use a long-handled hoe. The common implement used for cleaning operations in growing crops is a kind of Dutch-hoe of various shapes, some with long, others with short, handles.

The most important crop grown in the Nuba Mountains is dura (Sorghum). This forms the staple food of the community and between 30 and 40 varieties are grown.

Figures taken from "Colvin's Survey on the Nuba Mountains," made in 1939, show the areas under economic crops as follows :—

Sorghum	357,000	Feddans
Cotton	104,000	,,
Simsim (sesame)	89,000	,,
Bullrush Millet	30,000	,,
Earthnuts	30,000	,,
	610,000	,,

In addition to the above, small quantities of maize, onions, chillies, melons, tomatoes, okra, tobacco, and beans, are grown, mostly for domestic purposes.

The Commercial Cotton Crop.—Cotton was first introduced into the Nuba Mountains as a commercial crop in 1925, and by 1935, seven ginning factories, capable of dealing with all cotton grown within a 50-mile radius, were erected. These consist mostly of batteries of four Platt's or Dobson's Airblast saw gins, housed under one large building and capable of an output of 45 small 265 lb. bales of lint per

8-hour day. This sized bale is found the most convenient for camel transport. At the peak of the season some factories run 3 eight-hour shifts in the 24. The variety of cotton being grown commercially is " Pump Scheme," so called because it was originally supplied from the Government Pump Schemes ; its origin is somewhat obscure but is believed to be Nyasaland Upland which was itself a mixture of Allen, Sunflower, Florida, and Griffen, but Florida is said to have predominated. This heterogenous make-up has produced somewhat elastic material able to stand up to the many and varied soils and planting conditions met with. The lint is moderately good in quality, whitish, measures between 1″–1⅛″ in length and spins well at 50's. The disadvantages of Pump Scheme Strain are low ginning outturn, susceptibility to Blackarm disease, lateness and jassid susceptibility. Several other purer varieties have been tried, but up to the present none has proved successful, mainly because it lacked the disease resistance and general sturdiness necessary in order to compete with the varied conditions existing.

Inherent Plant Breeding Problems.—Perhaps the greatest problem the plant breeder has to face is the fact that cultivators sow when and where they like. The result is that some sow on heavy cotton soils, some on a light red sandy soil, some on hillsides, some on swampy land. One set of cultivators will sow dry in early June, while another set may sow as late as the end of August. No matter how hard the breeder tries to keep a strain of cotton up in quality and staple regularity, the commercial crop having been produced under these very varied conditions is bound to be irregular both in staple length and strength. The breeder is not catering for a highly systematized farming community (such as may be found in the Gezira or Egypt) which normally cultivates the same area, situated in the same locality, and planted at the same time each year with the object of obtaining the maximum return from a given area ; he is catering mainly for independent peasant farmers (most of them cattle owners) who grow cotton on whatever land they find most convenient and plant their crop at whatever time they find most convenient. Cotton is grown to provide these cultivators with sufficient money to enable them to pay their taxes and purchase a few clothes and household necessities to tide them over until next season. This being the case, it does not necessarily follow that by increasing the yielding capabilities of a variety in its output of seed cotton per feddan (all other factors being equal), more cotton would be produced, and should the breeder provide the cultivator with a very high quality cotton, he would have great difficulty in maintaining the quality. On the other hand, if the ginning outturn of the commercial cotton could be increased (other things such as seed weight and lint quality being equal) the actual revenue would be increased accordingly. For example, if we could have increased the lint output at Kadugli by 2% in season 1937–38, when seed cotton purchased amounted to 11,193,335 rottles, assuming the selling price of the extra lint obtained was 5d. per rottle, our revenue would have been increased by approximately £E.4,500.

Plant Breeding in American Types for Nuba Mountains.—After several years' testing, five new varieties are available, any one of which may prove more profitable to grow than Pump Scheme strain. These varieties are: N.T.205/41, Deltapine, N.T.96/40, N.T.58/39 and S.P.84(Rest.).

1. *N.T.205/41* is the most promising of these strains under Nuba Mountains conditions. It came from a selection made in 1940 from Uganda S.P.20 which itself arose from U.4/4/2. N.T.205/41 carries all the desirable attributes needed to make it a commercial success in the Nuba Mountains. It is *very* early, the lint is almost equal in quality to Pump Scheme, the ginning outturn averages 4·5% higher than the latter and the seed weight is slightly higher. The variety is heterogeneous for Blackarm resistance ($\mathbf{B}_2$), but a nucleus area composed of progeny rows homozygous for this character was grown in 1943–44 winter and provided ample seed both for varietal tests and for sowing a 20-feddan increase area at Shendi under irrigation next season. In addition to all these factors, N.T.205/41 is highly resistant to jassid and it has significantly outyielded Pump Scheme strain in every test at Kadugli, Talodi and Umm Berembeita.

2. *Deltapine* (a recent importation from America), in every Standard Varietal Test at Kadugli and Talodi for the past 3 years, has given significantly higher lint yields than Pump Scheme. The disadvantages of this variety are its low lint quality and its susceptibility to jassid. Its most desirable features are its earliness, high seed weight and very high ginning outturn (roughly 9% higher than Pump Scheme—typically 39% against 29%).

Deltapine shows a certain measure of resistance to Blackarm, but is by no means as resistant as typical " resistant " American types containing $\mathbf{B}_2$ and its resistance when examined genetically was found to be dependent on a number of minor genes. Accordingly $\mathbf{B}_2$ has been transferred from N.T.61/38 to this variety and second backcross material homozygous for resistance was bulked in 1943–44 winter for trial next season, whilst the transference was continued through later backcrosses.

3. *N.T.96/40*, a selection made in 1939 from a hybrid of 57×Over-the-Top, has for three seasons significantly outyielded Pump Scheme Strain in nearly all tests made. It is a large-bolled vigorous plant, fairly early and resistant to jassid. The lint is of better quality and on an average is valued slightly higher than that of Pump Scheme; the ginning outturn averages 2·8% higher. The variety is heterogeneous for Blackarm resistance, but steps are being taken to obtain a pure breeding resistant nucleus area next season.

4. *N.T.58/39*, a selection from a Punjab Early Strain outcross, is large-bolled, early, fairly resistant to jassid and heterogeneous for resistance to Blackarm. This variety usually spins better than Pump Scheme strain and its ginning outturn is usually 1–2% higher. In yield per feddan the two types are about equal.

5. *S.P.84 (Rest.)*. This strain represents the Blackarm-resistant element selected out from Uganda S.P.84R (see 1941–42 Report, page 81). It is early and has significantly outyielded Pump Scheme Strain but has not yet been tested against the other leading varieties in the Nuba Mountains. The ginning outturn is 4·5% higher than that of Pump Scheme and the variety is resistant to both jassid and Blackarm. The lint quality is slightly lower than that of Pump Scheme.

BAR.7/3, a bulk re-selection made out of progeny rows from S.P.84 (Rest.) was propagated for test in an isolated plot at Wadi Seidna, some miles north of Omdurman. This selection was made with a view to improving lint quality and ginning outturn and it will be on test next season.

On the breeding side, the transference of the Blackarm-resistance factor $\mathbf{B_3}$ from *punctatum* to SUS.7/2 was continued, the third backcrosses being grown in-season and the fourth backcross progenies out-of-season. This material is now ready for combination with S.P.84 (Rest.) and with BAR.7/3 next season in order to produce a highly Blackarm-resistant variety containing both $\mathbf{B_2}$ and $\mathbf{B_3}$.

In addition, two further backcrosses were made in transferring the Tanguis hairiness gene (**H**) to BAR.7/3 and seed of fourth backcross composition was obtained for sowing next season.

Equatoria Province.

Equatoria, with an area of 159,025 sq. miles and a population of 1,224,557, is the second largest province in the Sudan. Situated in the southernmost corner of the country, it adjoins Abyssinia, Kenya, Uganda, the Belgian Congo and French Equatorial Africa. Equatoria consists in the main of high grass savannah which gives place in the north and north-east to swampy grass plains and in the north-west to low grass savannah. Broadly speaking, in southern Equatoria a red laterite is the basic soil type and this is overlain by a grey surface soil in the valleys and plains. In the north this laterite gives place to the so-called "black cotton soil." Rainfall ranges from about 38 inches on the East Bank to an average of about 54 inches on the West Bank of the Nile.

Commercial cotton-growing started in Equatoria in 1927 when Government ginneries were built at Yei, Shukoli and Meridi. By 1931, however, the factories at Shukoli and Yei had closed after a series of disappointing results and in recent years cotton-growing in this Province has been centred on two ginnery areas—Meridi on the west of the Nile and Torit on the east. Torit area has never shown any great promise, partly because of the lack of interest evinced by the local tribes, and cotton-growing was discontinued in this area in 1942, except for experimental plots. The seed cotton yield of the Province as a whole had fallen from a peak of 22,000 large kantars in 1937 to 10,000 in 1939–40 and by 1943–44, as a result of the war, it had reached the low total of 828 kantars.

Cotton has never been a popular crop with the natives of Equatoria. The peak figure in 1937 represented the cumulative effect of several years under maximum propaganda, the fall from 1937 to 1939 was due solely to a cessation of Government propaganda. Since the war the cultivator has been discouraged from growing cotton on a large scale and the lack of purchasable commodities in the local shops has further reduced the incentive towards the planting of cash crops. According to Nalder (in " The Anglo-Egyptian Sudan from Within," 1935, page 110), " The economic development of the Southern Sudan is virtually prehistoric and has made little, if any, advance in the past hundred years." There are a large number of tribes but, except for the Zande, who, at the beginning of the war, had just started to appreciate the value of money, the mass of the population have no idea of its value and, like other primitive unsophisticated natives, are completely happy in their own surroundings. They have only one desire—to be left alone. Thus the increase of cotton areas, or, indeed, the increase of any cash crops, in the Southern Sudan is primarily a question of educating the population to a higher standard of living and only secondarily a plant breeding one.

Meridi district and the western half of Equatoria probably has a big future as a producer of American Upland cotton, although present production is small. Cotton, in this area, is likely to be considerably extended as a result of the policy laid down by Dr. J. D. Tothill, C.M.G., in his " Suggested Experiment for the Social Emergence of Indigenous Races in Remote Areas."

Cultivation.—In Western Equatoria land is prepared for cotton by digging with a small hoe after burning off rank vegetation and felling or ringing the trees. The usual sowing date is mid-July. The optimum date is probably early June, but the cotton crop would then compete with dura sowing and with hunting. Both spacing and seed rate are extremely variable and thinning to two plants per hole is an ideal which is rarely attained. The crop generally receives one or two hoeings. Picking starts in November and goes on till January. Average yields, calculated on large ginnery areas, vary from 250 to 500 rottles per feddan. The rotation is usually cotton for two or three seasons, then dura or other food crops until the soil is exhausted, and then a reversion to bush.

In the past, cotton has been grown both on flat land and on slopes with no attempt to control erosion. In recent years there has been a much greater awareness of the danger of erosion and any policy of expanding cotton cultivation in this area will, undoubtedly be carried out with suitable safeguards.

Plant Breeding Problems.—The greatest difficulty in breeding crops for Equatoria lies in the fact that there is no plant breeding station there so that all work intended to be of value in Equatoria is carried out under totally different climatic conditions from those in which the varieties will eventually grow.

The ideal cotton for Equatoria should be high-yielding and of good medium quality but should not shed its seed cotton readily if left too long between pickings; it should be capable of competing with weeds, inefficient thinning, and a minimum of cultivation. As in the Nuba Mountains, a high ginning outturn is of considerable importance. Resistance to Blackarm is essential on the east bank of the Nile and is desirable, as an insurance policy, on the west bank. In certain seasons *Ramularia areola* can cause defoliation, but the disease is not normally of much economic importance.

On the entomological side, *Helopeltis* can cause very severe damage, but such damage has so far always been localised and the pest is sporadic. Stainers (*Dysdercus* spp.) occur, but are not as serious a pest as in Kordofan. Jassids (*Empoascus*), cotton seedbugs (*Oxycarenus*), Egyptian bollworm (*Erias insulana*) and pink bollworm (*Platyedra gossypiella*) are all present.

Genetics, Breeding and Testings.—Five Standard Variety Tests were grown in Equatoria this season—two at Luluba on the east bank and one at Kagelu and two at Meridi on the west bank. The control type for the east bank was X.A.129 (grown there commercially until the war put a temporary stop to cotton cultivation there), and on the west bank, 511D, the present commercial type. In four of these tests S.P.84 (Rest.) gave the highest yield, and in the fifth (at Meridi) it was beaten by S.P.84 (Sus.) by a negligible margin. This latter strain represents the Blackarm-susceptible element selected out of Uganda S.P.84R. N.T.205/41 also showed considerable promise, while X.A.129 and 511D were the lowest yielders on the east bank and west bank respectively.

On the breeding side, much of the work discussed under the section on Kordofan Province is being directly used for Equatoria. In addition, the following lines of work are being carried out.

1. *511D*^{1} *(from Uganda S.G.85).*—This type already contains $\mathbf{B_2}$. The addition of $\mathbf{B_3}$ was proceeded with, the fourth backcross progenies being grown in 1943–44 winter and selfed in order to extract a $\mathbf{B_2B_3}$ type of 511D next season.

2. *X.A.129 (from Pump Scheme Strain).*—X.A.129 is fully susceptible to Blackarm. $\mathbf{B_2}$ has been transferred from N.T.61/38 and homozygous material of second backcross origin was bulked in 1943–44 winter for test in the south, whilst seed was produced for a homozygous propagation plot of third backcross origin next season. It is probable that the required type will be obtained from quite early backcrosses because N.T.61 is itself in the main of Pump Scheme Strain origin.

3. *Uganda B.P.52.*—Seed of this Blackarm-susceptible type was brought back from Uganda in August, 1942, and at once crossed with a resistant type. This season the first backcrosses (transferring $\mathbf{B_2}$) were grown, and second backcrosses, grown out-of-season, have yielded

third backcross seed for next year's crop. The transference of B_3 has lagged somewhat behind this programme owing to the difficulty of grading winter-sown material.

4. *Ginning Outturn Investigation.*—As mentioned in last season's report, Deltapine has a ginning outturn of approximately 40%, but has lint of poor spinning quality ; X.A.129 has a ginning outturn of about 30%, has lint of good spinning quality, and is well suited to conditions in Equatoria. This line of investigation was, therefore, started to examine the possibility of transferring some, if not all, of the high ginning outturn of Deltapine to X.A.129 without deleteriously affecting the lint of the latter.

Last season it was shown that the high Deltapine ginning outturn was partially dominant over the low ginning outturn of X.A.129. This season the first backcrosses were grown on a big scale plentifully interspersed with random holes of Deltapine, X.A.129, and of the F_1 of the varieties. The X.A.129 control holes gave a range of ginning outturn from 26% to 33% (individual plants) with a mode at 29% ; Deltapine ranged from 32% to 45% with a mode at 39% ; the F_1 ranged from 31% to 41% with a mode at 35% ; and the first backcross ranged from 24% to 36% with a mode at 32%.

First backcross plants showing 36% ginning outturn were selected for nearness to X.A.129 appearance and backcrossed again to X.A.129. A few were selfed and the second backcross progenies, and first backcross F_2 progenies, will be grown next season.

Section III.

Crops Other Than Cotton.

(*a*) *Dura* (*Sorghum*).

In last season's report a short note was given on the importance of the dura crop as the main food of the Sudan and on the percentage production in the various Provinces. In this report an attempt will be made to outline the main problems to be met with in any programme of dura improvement and the steps which are being taken to solve them, but before doing so it should be stressed that the work of dura improvement is seriously handicapped by the conservatism of the native whose preference for a particular dura for his food or drink is very difficult to overcome. As the problems vary widely from province to province because of differences of climate, tribe and customs, each province is treated separately.

In the Northern and Khartoum Provinces where rainfall is negligible, dura is grown chiefly by irrigation from pumping stations and water wheels (sagias) situated on or near the river. Flood land dura is also grown. The main factors limiting yield in these areas are :—bird-damage, which has almost completely stopped dura cultivation in certain parts of Northern Province ; the *Striga* parasite

(buda) which causes heavy losses every year ; and Stemborer (*Sesamia cretica*) damage which is particularly bad in areas of Northern Province such as Shendi.

In Kassala Province dura is mainly cultivated under rainfall, and under flood irrigation in the Gash and Tokar areas. In the latter areas excellent yields are generally obtained except in bad locust-years, such as the one experienced at Tokar in 1943 when almost three-quarters of the crop was destroyed. Yields in the rain areas are naturally dependent on the quantity and distribution of the rainfall and soil nitrogen, but midge and stemborer can often lower production considerably.

In the Blue Nile Province, which yields just over half of the total dura production of the country, 34% is obtained from rain cultivation, 16% from irrigation and 2% from flood land. In the rain areas the quantity and distribution of the rainfall is, of course, the major limiting factor of yield, followed closely by the nitrogen content of the soil. Added to these, however, are *striga*, birds, andat, stemborer, midge and mealy bug, each of which, in their turn or together, are capable of causing serious loss of crop. In the irrigated area *striga* is probably the worst of the factors affecting yield other than lack of nitrogen in the soil, particularly where, as in the Southern Gezira and at the Gezira Research Farm, dura follows cotton in the rotation. Again, in the Southern Gezira, where the rainfall is heavier than in the centre and north, weed growth can be a serious problem, and andat in some years reduces yields considerably. Birds, smut, midge, stemborer and locusts are also grave factors to be reckoned with.

In Darfur Province, where rain cultivation is practised exclusively, the quantity and distribution of the rainfall is naturally the most important factor, again followed closely by soil nitrogen. *Striga* is one of the worst of the organisms affecting yields.

In the Kordofan, Upper Nile and Equatoria Provinces, rain cultivation is practised almost exclusively, with the exception of a small area of flood-land cultivation in Kordofan. As in other rain areas, though not to the same degree because of higher rainfall, the quantity and distribution of the rainfall, the nitrogen content of the soil and the effect of weed growth are the major factors limiting yields. Because of the heavier rainfall and higher humidity of these areas, the choice of variety is a limited one, as most early-maturing and/or close-headed varieties will often not set and mature their grain, and if, as generally, their maturation periods coincide with a long spell of high humidity, the dura heads are invariably attacked by mould fungi and head borers of various kinds with disastrous results. Such conditions occur mainly in Equatoria Province.

From the above it will be seen that almost every Province has its own particular problems and thus the choice of variety must be provincial rather than general. It would seem that the native cultivator has realized the difficulty of obtaining any one variety

that would solve all his problems in any particular locality, and it is probably for this reason that the issue is confused by the multitude of varieties that are to be met with in any one Province, particularly in Kordofan, Upper Nile and Equatoria, where early-, medium- and late-maturing varieties are annually grown to suit the needs of local custom and as a safeguard against abnormal rain distribution. The solving of these problems is further complicated by three major factors : (*a*) distance and lack of easy transport ; (*b*) the natives' lack of urge to work hard or for long hours because of climate and his abiding faith in the goodness of Allah ; and as mentioned before (*c*) the native's strong conservatism as shown by his distrust of anything new, particularly in regard to his diet.

The Results for the Period 1940–1943.—The partial or complete solution of the above problems seemed only possible if the following lines of action were adopted : (1) The collection and study of all available local varieties. (2) The comprehensive testing of the most promising of the provincial varieties in their particular Provinces over a series of seasons to determine which were generally the best. (3) The introduction and testing of varieties from other countries.

(1) *The Collection and Study of Sudan Duras.*

It is estimated that some six hundred dura types occur in the Sudan and of these 375 have been collected, mainly since 1940, and studied at the Gezira Research Farm. Some sixty of these have shown partial, high resistance or immunity to the various Sudan forms of common smut.

Three hundred have been pot-tested for *striga* resistance and in all cases germinated and matured *striga* seeds—though such a result does not necessarily imply absence of resistance as has been demonstrated by one of the tested varieties in field trials.

Observations recorded for these types include maturation period, height, width and sweetness of stem, type of gassab (fodder), awness, colour of midrib (indication of sugar content of stem), type, size and compactness of head, glume colour, size and weight of grain, nitrogen and moisture content of grain, behaviour under field conditions to birds, *striga*, smut, etc., and yield under Gezira Research Farm conditions. Whenever these types have been tried out in varietal tests in other Provinces, notes on maturation periods and pests, and disease observations have been recorded.

(2) *The Comprehensive Testing of Promising Varieties.*

In the Northern Province results have been generally very disappointing for various reasons. Several of the former tests were not carried out as planned and the trial run in 1943 was almost completely destroyed by birds—only Dwarf Hegari, Mugud White and Dwarf White Milo, of the 8 varieties tested, gave yields of 500 or more rotls per feddan.

In Kassala Province an unreplicated trial of 12 varieties, under flood-irrigation in the Gash in 1943, demonstrated that two from the Northern Province were capable of outyielding the control. The 1943 trial at Tokar was completely destroyed by locusts, but the one carried out in 1942 showed that some of the introduced varieties, particularly one introduced from the Northern Province, were also capable of outyielding the control.

In the Blue Nile Province three seasons' tests at the Gezira Research Farm (*i.e.*, 1940–42) led to the growing of demonstration plots of Dwarf White Milo at each of the 39 Blocks of the Sudan Plantations Syndicate and Kassala Cotton Company, and the laying down of replicated variety tests in the North, Centre and South of the irrigated Gezira area. In the variety tests Dwarf White Milo outyielded the control (Feterita) by a mean of 25% in grain yield but produced 9% less gassab. In the demonstration plots Dwarf White Milo outyielded all the local feteritas against which it was tested by 18% grain and 25% gassab. Within the period 1940–1943, twenty-seven of the most promising commercial types have been tested for the irrigated Gezira and found inferior to Dwarf White Milo.

Similar tests have been conducted at the various White Nile Pumping Stations and have given similar results, *i.e.*, in favour of Dwarf White Milo. This variety, an importation from America, is immune to the Gezira form of common smut, has shown better resistance to *striga* and bird-damage than the generally grown Feteritas, possesses a better flour and so commands a higher price, and because of its slightly sweet stalk is considered a better gassab than Feterita. It matures 10–14 days earlier than most Feteritas and should thus need less irrigation—a considerable item on 120,000 feddans. Feterita is fully susceptible to common smut and for this reason its seed must be dusted with copper carbonate or sulphur prior to sowing. The cost of this is estimated at £720 per annum per 120,000 feddans. Should mechanical harvesting be introduced into the Sudan, Dwarf White Milo would have another advantage over Feterita as it will combine whereas the Feteritas will not.

In the rain areas of the Blue Nile Province replicated trials have been very disappointing. During the rains movement about the Province is very restricted as most roads are closed to wheeled traffic. For this reason sites have to be selected before the rains break and in almost every instance the sites chosen have received either insufficient rain or no rain at all and so the results obtained have been undependable. Unfortunately it has been very difficult to find a local cultivator on the spot who will co-operate in these trials, and for this reason future tests will take the form of demonstration plots the running of which does not require a high standard of intelligence.

In Kordofan Province the vast number of varieties generally grown made it necessary to eliminate many of them before replicated tests could be put down. In the period 1940–42 some ninety varieties

were grown, unreplicated, at three sites—Dilling, Kadugli and Talodi, which in their order range from light rainfall and light soil to heavy rainfall and heavy soil. Rainfall distribution and quantity differed quite considerably in these years and it was decided that sufficient evidence was available at the end of 1942 to allow of selection of the varieties giving the best mean performances in each maturation group at each site, and the testing of these in replicated trials in 1943. The results of these trials have justified the decision taken, as, of the 90 varieties originally tried, only 37 remain to be tested in 1944, *i.e.*, roughly the six best in each of the maturation groups. In the late maturation group Kulum has shown itself outstanding and is strongly recommended as the late maincrop type for the Kadugli and Talodi areas.

In Equatoria Province progress has also been achieved and of the forty-four varieties tried in 1942 only eight remain to be tested in 1944, and of these Karinaka, Monshal and Maga Ahmar show the most promise—the first and last are introductions from Kordofan Province. At Liria some success has been obtained with Dwarf Hegari and commercial areas were grown in 1943. Mr. Ferguson, of the Field Staff, has recently reported great success at Kagelu with varieties he imported from Uganda.

A replicated test carried out at Tessenei, in Eritrea, last year, through the co-operation of Capt. Congdom, was most instructive, and although none of the introduced varieties outyielded the local Aklamoi White, many of them were considered suitable for rain cultivation in this area.

No tests have as yet been carried out in the Khartoum, Darfur and Upper Nile Provinces.

3. *The Testing of Varieties Introduced from Other Countries.*

Mention has already been made of the success in the irrigated Gezira area of Dwarf White Milo from America. Another American variety, Dwarf Hegari, not only gives a high yield but has shown itself significantly more resistant to *striga* than the Feteritas. It has been fairly successful at Liria (Equatorial). *Striga*-resistant Kaffir varieties from South Africa have been tested without success and two new *striga*-resistant varieties have just been obtained from India and will be tested in 1944.

A number of varieties from the Belgian Congo have been grown but were not impressive.

Mention has already been made of the success in Equatoria of Mr. Ferguson's Uganda types.

Six new varieties have just been obtained from British Somaliland through the kindness of Capt. Congdom, of Eritrea, and requests for new varieties from America have been made.

(*b*) *Bamia* (Hibiscus esculentus).

Routine propagation of pure seed stocks of Momtaza bamia was carried out.

(*c*) *Camphor.*

Ocimum Kilimandscharicum is being grown in the Sudan as a source of camphor of which dried leaves contain about 1%. To see whether any genetic variability exists in camphor content, a number of single plants were harvested separately and grown as progeny rows. The variability in camphor content of the progenies was considerably greater than that of control rows, and two rows which showed a marked increase were carried forward for growing as separate bulks next season to provide adequate leafage for a more thorough testing. The present results indicate a strong probability that the camphor content of this crop can be raised by selection.

Summary and Conclusions.

Cotton.

Section I. Egyptian Types.

Tests of Blackarm-resistant X1730 (BAR.1730L) in the Gezira showed it to be typical X1730 in every way, but capable of outyielding the commercial X1730A wherever Blackarm was present. Spinning reports, from previous seasons, showed no difference between X1730A and BAR.1730L. This strain will, accordingly, go to an increase area in the Gezira next season with a nucleus of 9th backcross material.

Blackarm-resistant N.T.2 (BAR.2/41) was grown on 1,000 feddans in the Gash, and seed from this will be used to sow some 6,500 feddans in the Gezira next season.

Selection within the Blackarm-resistant strains of X1730 and N.T.2, carrying $\mathbf{B_2}$, was started in 1942–43, and some of the best progeny rows in each type were bulked this season for sowing in nucleus multiplication plots. Other specially selected plants will be sown in next season's breeding plots.

The production of X1730 and N.T.2 strains carrying both $\mathbf{B_2}$ and $\mathbf{B_3}$ was carried a stage further and propagation plots of these types will be grown at Shambat next season.

The transference of the four genes, $\mathbf{B_1}$, $\mathbf{B_2}$, $\mathbf{B_3}$ and **H** to Domains Sakel was continued, and second backcross seed was produced for 1944–45 sowing.

Selection for leaf curl resistance in Domains Sakel and in Massey's Selected Domains Sakel, is proving progressively effective.

The transference of Blackarm immunity from *G. Sanguineum* to Sakel was taken to the third Sakel backcross stage.

Selection for early maturity has been undertaken in Domains Sakel, Blackarm-resistant X1730, and Blackarm-resistant N.T.2. At the same time work designed to improve the staple regularity and quality of these three strains has been started.

In breeding for jassid resistance, the transference of the Tanguis hairiness gene to Domains Sakel, X1730 and N.T.2 was continued, whilst hairy strains of X1530 origin are being re-selected and tested in the breeding plots and at outstations.

A presumed hexaploid (2n=78) of *G. armourianum* × Sakel origin was obtained. This is itself fertile and is fertile in backcrossing to Sakel. It is hoped to transfer the pink bollworm-resistance of *armourianum* to Sakel by backcrossing from the hexaploid.

Section II. American Types.

(*a*) *Nuba Mountains.* Here N.T.205/41 (derived from Uganda S.P.20) shows most promise. It is very early, has lint quality almost equal to Pump Scheme, has a higher yield and higher ginning outturn, and is resistant to Blackarm and jassid.

Deltapine has consistently outyielded Pump Scheme, but lacks quality and is only slightly resistant to Blackarm; resistance has been transferred and the product is available for testing.

S.P.84(Rest.), the Blackarm-resistant element from Uganda S.P.84, showed considerable promise, but requires more comprehensive testing. The transference of an additional Blackarm-resistance factor ($\mathbf{B_3}$) to this type was carried a stage further as was the transference of Tanguis hairiness.

(*b*) *Equatoria Province.* 511D (from Uganda S.G.85) is the commercial type on the west bank. It is already Blackarm-resistant ($\mathbf{B_2}$) but $\mathbf{B_3}$ is being added to increase this resistance.

X.A.129 was the commercial type on the east bank until production ceased owing to war. It was susceptible to Blackarm, but has now had $\mathbf{B_2}$ transferred to it and an attempt is being made to transfer some of the high ginning outturn of Deltapine to this type by backcrossing.

S.P.84(Rest.) showed most promise in both eastern and western Equatoria, but was fairly closely followed by N.T.205/41.

The transference of Blackarm-resistance to Uganda B.P.52 was carried two backcrosses further.

Crops Other Than Cotton.

(*a*) Dura (*Sorghum*).

Of about 600 dura types occurring in the Sudan, 375 have now been collected and studied. About 60 of these showed resistance (ranging to immunity) to the Sudan forms of common smut.

In Blue Nile Province, Dwarf White Milo has consistently outyielded Feterita. At 1943 prices the yield differences would have produced an extra £E.250,000 to the Gezira cultivators had this been the standard variety. Dwarf White Milo is immune to the Gezira forms of common smut, has shown better resistance to *Striga* and bird damage than Feterita, possesses a better flour and commands a higher price than Feterita. The stalks are sweeter and hence better cattle feed, and the variety matures 10–14 days earlier than most Feteritas.

Of the 90 dura varieties grown in Kordofan Province, 53 have been eliminated, leaving 37 for testing next season. Of the late-maturing types " Kulum " has shown itself outstanding and is strongly recommended as the late main crop type for the Kadugli and Talodi areas.

In Equatoria " Karinka," " Monshal " and " Maga Ahmar " show the most promise.

(*b*) Bamia (*Hibiscus esculentus*).

Routine propagation of pure seed stocks of " Momtaza " bamia was carried out.

(*c*) *Camphor.*

The variability in camphor content as between progeny rows of *Ocimum Kilimandscharicum* was considerably greater than between control rows, indicating a strong probability that the camphor content of this crop can be raised by selection.

PROGRAMME OF EXPERIMENTS 1944-1945.

Cotton.

Section I. Egyptian Types.

All lines of work shown in this section will be continued except that Domains Sakel will be concentrated on, especially in Blackarm-resistance hybridization, largely to the exclusion of N.T.2.

Section II. American Types.

Work is to be concentrated on the improvement of promising strains and further selections made from N.T.58, S.P.84, N.T.96, N.T.205, N.T.206 and Deltapine will be tested against their parents, and, in order to see the effect of Blackarm-resistance on yield of seed cotton, some ten strains of resistant and susceptible cottons will be tested in ten replicated rows using a similar technique to that described by J. B. Hutchinson. In addition, the usual varietal tests will be carried out at Kadugli and Talodi.

Isolated increase areas have been arranged for Deltapine new selections, N.T.58 new selections, S.P.84(Rest.), N.T.96, N.T.205(Rest.), N.T.206 and N.T.209.

Observation plots of four long-stapled American cottons will be grown by the Sudan Plantations Syndicate at Zeidab.

Crops Other Than Cotton.

Dura (*Sorghum*).

A number of replicated variety trials will be grown in Northern Province, Kassala Province and Eritrea, Blue Nile Province, Kordofan Province and Equatoria.

There will be a bird-resistance trial of 350 types and observations will be made on 350 types and 40 hybrids of commercial parentage, at Medani.

The value of ratooning dura will be tested at Medani, also the effect on *striga* of burning off a ratoon or broadcast dura crop following harvest.

Finally, the keeping qualities of several varieties will be tested under field-pit storage conditions.

No experiments are at a stage at which a detailed report is justified. No Part II of the Report is accordingly required.

Acknowledgments.

We are indebted to Messrs. W. P. Archdale (Manager, Sudan Plantations Syndicate) and A. Gaitskell (Assistant Manager), for much of the information supplied concerning the Gezira cultivation. Free use has been made of :—*Soil Problems of the Anglo-Egyptian Sudan,* by Dr. H. Greene. Empire Journal of Experimental Agriculture. Vol. V. No. 17. January, 1937. *Cotton Growing in the Tokar Delta,* by E. Mackinnon (Sudan Government Department of Economic and Trade Bulletin 4, 1938). *A Survey on the Nuba Mountains,* by R. Colvin (Senior Inspector of Agriculture, El Obeid, 1939).

PUBLICATION.

Knight, R. L.—The Theory and Application of the Backcross Technique in Cotton Breeding. *J. Genet.* (in the press).

Appendix.

Key To Symbols Used in this Report.

Genes.

B_1 A dominant, weak Blackarm-resistance factor derived from American Upland (Uganda B.31).

B_2 A dominant, strong Blackarm-resistance factor from American Upland.

B_3 A strong, partially dominant Blackarm-resistance factor from *G. punctatum.*

H A hairiness factor from Tanguis.

R_2^{RS} A factor governing reddish flowers and leaves, from *G. arboreum.*

Varieties.

X1730A.	Selection from X1730 in 1931 and now grown commercially.
BAR.1730L.	Blackarm-resistant X1730 of 7th backcross origin and containing B_2.
N.T.2.	A selection from Sakel resistant to leaf curl.
BAR.2/41.	Blackarm-resistant N.T.2 of 7th backcross origin and containing B_2.
M.S.D.S.	Massey's Selected Domains Sakel.
N.T.58/39.	A selection made from a Punjab Early Outcross, bulked in 1939.
S.P.84(Rest.).	S.P.84 homozygous for Blackarm-resistance.
S.P.84(Sus.).	The susceptible element separated at Shambat from the heterogeneous whole.
N.T.96/40.	(57 × Over-the-Top) from Nyasaland.
X.A.129.	From a single-plant selection in Pump Scheme Strain.
511D.	From a single-plant selection in Uganda S.G.85.
BAR.7/3.	A re-selection from S.P.84(Rest.) for quality and ginning outturn.

Pump Scheme Strain. Local commercial cotton from Nyasaland Upland.

Deltapine. A commercial type from Delta & Pineland Co., U.S.A.

[*Included by courtesy of the Uganda Government.*]

UGANDA.

COTTON EXPERIMENT STATIONS, KAWANDA AND SERERE, PROGRESS REPORTS FOR THE SEASON 1943-44.

KAWANDA AREA

BY

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Part I.

Introduction.

Inherent Agricultural Circumstances.—Tropical rain forest is the climax of the area served by Kawanda, but much of this has been cleared and Elephant Grass (*Pennisetum purpureum* Schum.) is the dominant secondary vegetation. Topographically the area is a dissected peneplain and a regular sequence of soil types occurs between the flat hill tops and the swampy valley bottoms. Slopes of 5–15% are common, and erosion becomes a real danger as soon as cultivation has reduced the structure of the soil to a critical level. The climate[1] is relatively cool and humid. Rain falls throughout most of the year, with maxima in April–May and October–November. Above the level of the on- and off-shore breezes (confined to areas within some 20 miles of Lake Victoria) the prevailing wind direction is easterly at all times. The sustained heavy rain of April results from the convergence of two air masses ; one from the southern Indian Ocean, the S.E. Trade, which passes both to the south and north of the Kenya Highlands ; the other the retreating N.E. monsoon which has its origins in India and beyond and reaches Uganda mainly by the north of the Kenya Highlands. The May rains are due almost entirely to instability in the south-easterly air mass. In November convergence is again apparent. It is then the turn of the S.E. Trade to retreat, and there is an inflow of relatively moist air with the onset of the N.E. monsoon. Should one of the air masses retreat before the other can reach it, convergence does not occur and the rains fail or are unreliable. This unreliability is more marked in November as the N.E. monsoon is not characterised by the same degree of instability as the S.E. Trade. The rainfall maxima are associated with the onset of the Trade or monsoon. As soon as either the one or the other becomes established the sustained rains cease. The established air mass gives rise to little or no rain along its main path (along the East African coast), but temporary increases in

[1] The assistance of the British East African Meteorological Service is gratefully acknowledged.

moisture content and decreases in temperature (*i.e.*, temporary decreases in stability), which occur after the incidence, are of great significance in the branch which penetrates to Uganda. The lakes introduce quantities of water vapour into the air current on its westward travel and this adds to the latent instability, causing local thunderstorms. These can occur at any time, but are least frequent in January, February, June and July. Instability rains occur occasionally as a consequence of the penetration of westerly winds from the Congo. The rainfall gradient away from Lake Victoria is very steep, that from Entebbe to Kampala being no less than half-an-inch per mile on annual totals. January and February are the hottest and driest months, temperatures of 90°F. with humidities of 40% to 50% being frequent. June and July are the coolest months, temperatures being about 5° lower than in January and February.

Native Agricultural System.—Bananas (plantains) are the staple diet and tie the people down to a relatively fixed abode. The land occupied by annual crops is used in haphazard fashion with no settled rotation (often cotton continuously for several years), but when it is allowed to revert it does so principally to elephant grass, and the recovery of soil structure under elephant grass is remarkable[1]. There are few cattle, owing to worry by the biting fly *Stomoxys*, and manure plays no part in the system at present. There is some tendency for sweet-potatoes to increase at the expense of bananas, particularly near Kampala, owing to the depredations of the banana weevil, *Cosmopolites sordidus*, Germ. But as yet there is little likelihood of a general change over from a perennial to an annual staple food crop. Cotton cultivation has reached all likely places, including marginal areas, so that saturation point has been reached. This applies to the whole country, and in the area served by Kawanda the advent of an alternative crop more obviously suited to the climate would probably cause some recession in cotton cultivation. The population density is about 50 persons to the square mile (range over broad units of country 25–100), and considerable numbers of immigrant labour are employed. There is no system of debt and credit, and all transactions are for cash.

Native Agricultural Practices.—The general yield level is high, that of cotton (unginned) probably lying between 450 and 500 lb. per acre. Cultivation is entirely by hand. It has been mentioned that there is no settled rotation, but cotton is frequently intercropped with beans. The present cotton planting season lasts from May to September, the peak being in July, although earlier planting appears to give better results. This situation arises in part from the necessity to deal with food crops first, but consideration of the rainfall indicates that the position would bear further enquiry. The close season is strictly enforced. The spacing recommended, 3 ft. by 1 ft., is a little beyond the optimum, but present practice (which is only recent in development) is well within the range where small differences have but

[1] Martin, W. S. (1944), *Emp. J. Exp. Agric.* xii, p. 21.

little effect on yield. The first seed bed after elephant grass is very rough (an advantage for soil conservation). Subsequent cultivation incorporates the trash in the soil, until, by the time the seed bed is prepared in the second year, there is practically nothing left. Standing elephant grass is invariably burnt off before breaking new land.

Ecomomics.—Cotton is well established at the present time.

Cotton Varieties.—BP.52 has set a very high standard in the matter of staple. The chief need at the present time is for resistance to Blackarm, as BP.52 does not contain any gene for resistance. Greater resistance to *Verticillium* wilt would also be an advantage. Owing to the depredations of *Lygus* all varieties tend to yield alike, so that breeding for yield cannot be pursued satisfactorily by the ordinary simple methods of selection.

Seed Supply.—This would be more effective if the first wave of a new variety were regarded as a " washing out " process, and were invariably followed by a second wave of the same seed. The first 20,000 acres are attained by means of a series of segregated areas. But in the existing scheme some effectiveness is lost because the areas are not contiguous and do not cover one another.

Use of Seed.—Oil extraction has developed extensively during the war. Seed is also used for manuring non-native estates (coffee and rubber), and for cattle food in Kenya.

Conclusions from Work Done in 1943–44.

Meteorology.

The total rainfall at Kawanda in 1943 was 31·07 inches, the average for the seven previous years being 47·51 inches. This serious deficiency was due to failure of the second rains after mid-September, and had a profound effect on the latter history of the cotton crop.

Agriculture.

The programme was not extended (see Report for 1941–42, p. 94). But an examination of the rainfall records accumulated by the British East African Meteorological Service revealed that Kawanda differs from Bukalasa in its rainfall régime as much as Bukalasa differs from Serere. It was decided therefore to enquire further into the sowing date position in central and southern Buganda in the coming season.

Interplanting of Cotton.—This was confined to interplanting cotton with beans at different relative sowing dates in simple observation plots. In general a relative gain in one crop was at the expense of the other, though the total produce tended to be worth more than cotton alone.

Genetics and Breeding.

Genetics of Seed Type.—The progenies of three single plants heterozygous for green fuzz each segregated in close (and statistically significant) agreement with the hypothesis of a 3 : 1 ratio green to

white, indicating that the local type of green fuzz is determined by a single dominant factor. The inheritance of the naked and fuzzy tip characters proved to be complex, and apart from evidence of different types of dominance working in contrary directions, no conclusions were reached. It has to be remembered that the local cotton, though predominantly *G. hirsutum*, contains remnants from early introductions of *G. barbadense*.

Genetics of Blackarm Resistance.—Knight's method of gene transference was pursued to the fourth backcross from B.181 to BP.52, and to the third backcross from Gambia Native to BP.52. The transference of the gene $\mathbf{B_3}$ from Gambia Native to BP.50 was abandoned, as there was evidence at Serere that the original stock of BP.50 was itself heterozygous for at least one factor. The transference of $\mathbf{B_3}$ from Gambia Native to the most highly resistant strain of B.181, in order to combine all available genes in one strain, reached the third backcross. Single plants were taken from the F_2 generation of a simple hybrid between the related strains BP.52 and resistant N.17, which was made at Serere in the previous year. The next generation completes the attempt to obtain, by a short cut, a resistant type not greatly dissimilar from BP.52.

Since the chief virtue of BP.52 is staple rather than plant type the successive backcrosses in the transference of resistance from B.181 are being selfed and sorted. It is possible that the best agricultural type, with the requisite staple, may be reached before the prescribed programme of sevenfold backcrossing is complete.

Genetics of Resistance to Verticillium Wilt.—In 1938–39 it was established at Bukalasa by the method of covariance with alternate controls (though not reported) that there were large and statistically significant differences between families in resistance to *Verticillium* wilt. BP.50 was most susceptible, B.181 was highly resistant, whilst BP.52 occupied an intermediate position comparable with Buganda Local, which was then control. This suggested that an attempt should be made to establish a genetic basis for resistance, but the evidence of the hybrids then available was dubious and new material had to be worked up. This season the stage was reached when pollen was transferred from wilted plants of a susceptible sub-strain of BP.50 to healthy plants of a resistant sub-strain of B.181. The hybrid progeny will receive a soil inoculation of *Verticillium*, and afterwards be selfed and backcrossed both ways.

Genetics of Red Plant Body.—This work was transferred from Serere. The red character is a useful example for staff and students, and is also used for marking plot borders in variety trials. The backcross from Bukalasa Red to BP.50 segregated in close (and statistically significant) agreement with the hypothesis of a 1 : 1 ratio, indicating that the red colour is determined by a single dominant factor. It seems possible to distinguish the heterozygote, dominance being not quite complete, as red plants selected from F_2 have all bred true.

General.—The older simple hybrids and first backcrosses have produced nothing to be compared with the results of gene transference by continued backcrossing. Some re-selections have taken their place in variety trials, but further work on these lines has been discontinued.

Maintenance.—The maintenance of BP.52 in a pure state is of great importance for refreshing seed supplies in Buganda and for use in later backcrossing work. The seed sent to Serere in 1941 and multiplied there is the purest stock we have (due no doubt to better conditions for isolation at Serere), and is being sent back to Kawanda. 235 single plants have also been selected, first in the field and then in the laboratory, at Kawanda.

The type collection has been maintained. No types unrelated to our own cottons have proved to be worth pursuing in the ordinary variety trials, but several have been used in hybridization.

Variety Trials.—Apart from obvious differences in ginning percentage and the incidence of wilt the principal variety trial at Kawanda, containing 25 varieties, gave no information whatever.

Twelve district trials were planted with BP.52, B.181, BC.5/14 (F_6 seed of a selection from the first backcross from BP.52 to B.181), and X.3/38 (F_5 seed of a mixture three parts BP.52 and one part B.181). Two trials were spoiled. In the remaining ten all four varieties yielded equally on balance, and there was no tendency for local differences to group into a consistent geographical pattern. B.181 usually leads in this kind of company, but being a late maturing variety it was at a disadvantage in such a dry back-end. The fact that the backcross and mixture yielded equally with BP.52 may be important ; if required for a particular purpose, such as resistance to Blackarm, they might be tenable varieties pending results from the gene transference programme.

Spinning Tests.—BC.5/14 and X.3/38 (Kawanda produce in the previous season) gave quite satisfactory results.

Seed Distribution.—BP.52 was supplied to the rest of Mubende-Toro Zone, thus completing all Buganda, save Masaka Zone to which the variety is not suited judging by the results of earlier trials. In Masaka a remote area somewhat under 1,000 acres was planted with X.3/38 from Entebbe Segregated Area. Owing to the dry season the multiplication achieved was only threefold. In Mubende BP.52 suffered from Blackarm to an extent which served to focus attention on the need for a resistant type.

Plot Technique.

Owing to concern arising from the paucity of information proceeding from variety trials and other experiments at Kawanda an area of cotton of about two-thirds of an acre was harvested as a uniformity trial. The available material which was used might

not stand rigorous criticism, but the data nevertheless indicated that the results from uniformity trials at Barberton and Serere are not applicable to Kawanda. The experimental area lay on a slope of about 6% and pronounced fertility changes were found in a gradientwise direction. Since the rows of a crop are necessarily in a contourwise direction the plot arrangements adopted almost as a matter of course in past experiments (axis along the contour) is not efficient. Having obtained this information, an area of maize of just over three acres, which had dried out in the drought, was weighed as stover. This enquiry was somewhat academic, but it was assumed that the weights could be taken as a reasonable measure of soil differences, and an exactly similar result was obtained. This investigation is proceeding in consultation with Dr. Yates of Rothamsted.

Entomology.

As Dr. Taylor has left Uganda it is expected that his work on *Lygus* to date will be published before long.

Mycology.

Blackarm and wilt have been dealt with under the heading of Genetics.

PROGRAMME FOR 1944-45.

Agriculture.

Rotations.—The several blocks comprising the experiment farm at Kawanda will be organized to test three rotations (*a*) cotton in first year only, (*b*) cotton in second year only, after sweet potatoes, (*c*) cotton in first and second years.

Interplanting.—Will be omitted for one year pending the organization of rotations.

Sowing Date.—Conclusions reached from the rainfall survey will be followed up by means of isolated out-of-season plots at Kawanda, and possibly in an area south of the equator.

Planting Methods.—The heavy seed rate prevalent in Buganda has prompted an experiment on seeds per hole and thinning time on the lines of the Barberton experiments.[1]

Genetics and Breeding.

No changes in the Programme.

REPORT—Part II.

There are no detailed experimental results to be recorded in Part II of the Progress Report this year.

[1] MacDonald, D., Fielding, W. L. and Ruston, D. F. (1939), *J. Agric. Sci.*, 29, 418.

SERERE AREA.

PROGRESS REPORT—Part I.

BY

J. D. JAMESON and P. E. WEATHERLEY.

Introduction.[1]

Inherent Agricultural Circumstances.—The area served by Serere is predominantly orchard bush. The country is undulating, and again there is a regular sequence of soil types from the crests of the ridges to the swamps. Slopes of 3–7% are common, and sheet erosion menaces older cultivated land, particularly as the soils have less body. The climate[2] is hotter and drier, although the total annual rainfall is greater. The rainfall régime is similar to that of northern Uganda generally, giving an extended rainy season from March to October with maxima in April and September. The mechanism of the April–May rains is similar to that for Kawanda, but the reason for the resumption of the rains after July is not very apparent. The explanation is probably to be found in the enhanced instability produced in the south-easterly air mass as it proceeds across the swamps and lakes of Uganda. January and February are the hottest and driest months, humidities of 20% with temperatures of 95°F. being frequent. June and July are cool, but yield twice as much rain as at Kawanda.

Native Agricultural System.—Shifting cultivation and bush fallow are the basis of the local agriculture, but a more orderly system of resting cultivated land under grass without moving home is now widely adopted. Though there are many local differences, millet (*Eleusine*) is the principal staple diet. Cotton is usually the first crop on newly opened land and is generally followed by *Eleusine*, so that cotton planting ensures an ample acreage of the staple food in the next season. This is a very satisfactory basis for the rotation, which continues with other crops according to local preference. *Eleusine* is seldom sown a second time on the same land, but cotton may be. There is ample stock in most areas, but the manure is not used systematically. Banana cultivation is increasing in favoured situations (quite apart from those districts which are geographically intermediate between the Serere and Kawanda areas), but there is no likelihood of a change over from annual to perennial cropping. The population density is about 100 persons to the square mile over a wide area, but falls to 25 in the remote districts. There is no immigrant labour, and cultivation is done entirely by the family unit, although in some areas several families combine for certain operations such as harvest. There is no system of debt and credit.

[1] The references and comparisons are to the corresponding section on Kawanda, and omissions indicate that the Kawanda section can be applied to the whole country.

[2] The assistance of the British East African Meteorological Service is gratefully acknowledged.

Native Agricultural Practices.—The general yield level is lower and much less certain than in the Kawanda area, the level for cotton (unginned) ranging from 350 pounds per acre down to very low figures, with a mean about half that in the Kawanda area. But because cultivation is easier with short grass and lighter soils, the return from a given unit of effort is probably greater. Ploughing with oxen is general in several districts, but all other cultivation is done by hand. No dependable system of intercropping cotton with other crops has yet been found. The cotton planting season lasts from April (in some areas) till August. The peak is still in July, although earlier planting appears to give substantially better results. Food crops must be dealt with first, and labour distribution (in terms of the "man-weather-day") may be a limiting factor; but the results of sowing-date trials conducted on small contiguous plots must be accepted with some reserve, and furthermore late plantings ripen more rapidly and possibly give a better return in relation to work expended. The spacing recommended is 3 ft. by 1 ft., and that has for several years been well within the range where small differences have but little effect. The seed bed is fairly rough in the first year. Strip cropping has found widespread acceptance in Teso District, and is one of the most remarkable developments of recent years.

Economics—Cotton has no rival at all.

Cotton Varieties.—Without belittling the importance of cotton breeding, the most obvious opportunities for development lie overwhelmingly in the realms of fertility and agronomy. The depredations of *Lygus* are very severe, and almost completely obscure ordinary varietal characteristics in the field. Blackarm also is important, and is liable to cause very serious damage in some districts. BP.52 has been admitted to two small zones, and SG.29 (which also does not contain any gene for resistance to Blackarm) still remains in another two zones. But N.17, which fills the great bulk of the area, and the newer varieties which are being tried on a small scale, do contain some factor for resistance.

Greater stability in yield is the pressing need at Serere. The only approach to this problem is to diagnose the causes of instability and resolve them (or at least some of them) one by one, giving first place to soil improvement.

Seed Supply.—The position is the same as at Kawanda except that the segregated areas are continguous and therefore cover one another.

Conclusions from Work Done in 1943–44.

Meteorology.

The total rainfall at Serere in 1943 was 39·18 inches, the average for 23 years being 53·46 inches. This deficiency was due to the failure of the second rains from September onwards, and cotton set practically no top crop.

Agriculture.[1]

Manurial Trial.—This was the second year of the fourth cropping cycle (eleventh year) and the experiment was cropped with *Eleusine* followed by cotton. Yields were very low, particularly from the late-planted cotton, but the effect of farmyard manure was enormous, *Eleusine* on the heavily manured plots giving seven times as much as control.

Cotton Seed and Meal Manurial Trial.—This was resting under grass.

Cotton Seed and Ash Manurial Trial.—The first cropping cycle was wound up with *Eleusine* followed by *Vigna* under *Cajanus*. This was the third crop of *Eleusine* in successive years (not normal practice, but with intent to see what would happen) and it was spoilt entirely by the high proportion of *ekitu* or " wild " heads appearing in the crop. It is not yet known whether these are *E. indica* growing as a cumulative weed in the crop, or whether they arise by hybridization or other genetic process in the crop.

Both manures produced big (residual) effects in the yield of *Vigna*.

Fertility Experiment.—This experiment proceeded according to plan, and further results accumulated, all of them on the same lines as previously. As the resting treatment " *Cynodon* slashed " has not been found to simulate grazing, each cycle, as it comes round to its second cropping and resting circuit, will adopt " *Cynodon* grazed " instead. This has been found practicable using " Ringlock " fencing, and Dr. Yates's consent on statistical grounds has been given.

Interplanting Experiments.—The programme was in abeyance owing to the infestation of the land at Serere with *Digitaria scalarum* Chiov., and to lack of staff at Ngetta.

Planting Methods Experiment.—The previous year's trial concluded the investigation.

Gap-filling Experiment.—The experiment was repeated at Ngetta, but not at Serere owing to the trouble with *Digitaria*. This concluded the programme, and the results are dealt with in Part II of this Report.

N.P.K. Experiment.—This experiment was repeated on an acre field. The land was newly cleared and in good heart, and it was not surprising therefore that the first crop (cotton) gave but few results. The experiment will be continued on the same land.

Genetics and Breeding.

Genetics of Seed Type.—Detailed study was discontinued at Serere.

Genetics of Blackarm Resistance.—The progenies of 3,000 resistant phenotypes (representing 110 strains) were sprayed with Blackarm suspension. After exercising a certain amount of selection for other

[1] With the assistance of Mr. R. K. Kerkham.

characters, 328 resistant genotypes (representing 56 strains) were isolated and harvested. It was probable that more than one gene was involved. The method adopted was to uproot all those progenies containing plants which did not conform to our Uganda standards of resistance. The selected progenies should therefore be homozygous for at least one gene, but detailed information on the Mendelian behaviour of the genes involved was not obtained. The purpose of this undertaking was to convert all our heterozygous material into lines homozygous for one or more genes, rather than to enquire into the exact genetic constitution of all the strains one by one. The selected progenies will be tested again in the coming season.

Resistant phenotypes were selected from the F_2 generation of the simple hybrid between BP.52 and resistant N.17 (duplicated at Kawanda).

Type Collection.—This was maintained and extended.

Variety Trials.—There were two trials at Serere, one of ten varieties in a Latin Square of three sowing dates, and another of sixteen varieties in Lattice Squares. In general Bukalasa strains again yielded better than Serere strains. Within the Serere strains selections from N.17 yielded better than bulk. Two hairy cottons, Malwa Upland 8.A and O/SP.16 from Ukiriguru, were included in the second trial to observe their reaction to attack by *Lygus*. The behaviour of O/SP.16 was not notable in any respect (yield or jassid, besides *Lygus*). MU.8A, however, attained a degree of resistance to jassid not previously recorded for any other strain tried in Uganda. It was attacked quite severely by *Lygus*, but to a lesser extent than any other strain in the trial, statistical significance being attained by the leaf damage count. The lint yield of MU.8A was significantly greater than that of any other strain, and more than double control. Malwa Upland is a style of cotton not normally tried in Uganda, so that this large yield may be entirely a matter of varietal fruiting capacity ; nevertheless the possibility of increased yield being in part due to reduced *Lygus* attack merits further consideration.

District variety trials were conducted at twenty centres as usual, but a new 5 by 5 Latin Square design was everywhere adopted ; firstly to meet the dimensional requirements of strip cropping, and secondly to reduce edge effects by substituting rows of red cotton for paths. BP.52, B.181 and two selections from N.17 were tried at all centres against N.17 bulk as control (SP.84 in Usuku). B.181 was the most resistant to Blackarm throughout, and most notably it had much less Blackarm than SP.84 (ex U.4/4/2) in Usuku. In general, B.181 gave the highest yield of lint everywhere except in the north-west of Uganda, and it yielded more than SP.84 in Usuku. But S.2103 (ex N.17.M 2) was very close behind B.181, and ahead in the north-west. BP.52 was fully the equal of N.17 bulk, but did not do so well relatively as in the previous season. S.1103 (ex N.17.M 3) was also fully the equal of control.

Out-pollination Test.—Misgivings concerning the extent of natural out-pollination in Uganda have already been expressed (Report for the Season 1941–42, p. 95). An oblong quarter-acre was planted with a cotton having red plant body, and in this six green plants were inserted in positions corresponding to the six pips of a domino. The produce of these six plants was harvested separately and the seedling progeny examined for red colour (which is controlled by a single partially dominant gene, see Kawanda Report above). The over-all rate of out-pollination was 30%. The red strain used was not homozygous, but selection for homozygotes was exercised at thinning time. The figure obtained must therefore be regarded as perhaps slightly on the low side.

The experiment is to be repeated at Kawanda using a modification suggested by Mr. Prentice, namely, plants with lacineate leaves (a recessive character) in a field of normal cotton.

Spinning Tests.—Tests on 10 lb. samples from the 1942–43 season demonstrated the superiority of BP.52 over Eastern Province cottons generally, the difference being more marked at Serere than in Busoga district. The small-scale tests gave first place to S.1103, with BP.52 second, and recent derivatives of B.181 (noted for their very high resistance to Blackarm) quite close behind.

Seed Distribution.—Serere grew one acre of the latest N.17.M 2 strain, three acres of B.181, seven acres of the latest N.17.M 3 strain, and forty acres of BP.52. Mulondo was supplied with S.1103, and Labori-Kadunguru was "washed out" with a mixture of related N.17 strains which had been largely freed from black seed. The rest of the Serere segregated area grew N.17 bulk again. Many districts produced such a small crop in the 1942–43 season that they could not supply their own seed. Consequently a bold policy of replacement had to be adopted. West Acholi and Bunyoro Zones and a small portion of the West Nile-Madi Zone were supplied with BP.52, replacing SG.29. East Acholi, North and South Lango, and North and South Teso Zones had to be supplemented with N.17 from Busoga. As the seed of N.17 in North Lango was the purest remaining, this was particularly unfortunate, but an endeavour was made to concentrate the "home" seed in certain defined areas with a view to redistributing the produce. Usuku continued to grow SP.84. B.181 was supplied from Kawanda to the Lalle peninsula in North Teso. A small area of BP.52 was established in the South Mbale Zone, replacing SG.29. The multiplication of N.17.M 2 strains in Busoga was continued, the orginal N.17.M 2 reaching the whole of one county.

Entomology.

See Kawanda Report. Apart from *Lygus* there were no pests of note.

Mycology.

Blackarm has been dealt with under the heading of Genetics.

PROGRAMME FOR 1944-45.

Agriculture.

Manurial Trial.—To continue.

Cotton Seed and Meal Manurial Trial.—Resting.

Cotton Seed and Ash Manurial Trial.—Resting.

Fertility Experiment.—To continue.

Interplanting Experiments—The 1942–43 experiment, cotton with cassava and pigeon pea, to be revived with modifications.

N.P.K. Experiment.—To continue.

Genetics and Breeding.

Genetics of Blackarm Resistance.—Material obtained to be multiplied and tested in trials.

Type Collection.—To be maintained.

Variety Trials.—Routine.

PROGRESS REPORT—Part II.

Cotton Gap-filling Experiments at Serere and Ngetta.

Gap-filling in native cotton plots has been recommended by the Department since quite early times. The results of work done at Barberton[1] indicated that the value of this practice should be tested experimentally under Uganda conditions. The present series of experiments was carried out at Serere and Ngetta, and therefore refers only to the short-grass areas of Uganda. Similar experiments have not yet been done in the long-grass areas.

The variety used throughout this series of experiments was N.17, the standard variety of the area. It is a woody variety, which makes a large bulk of vegetative growth, but it is typical of the style of cotton which is grown throughout Uganda. Gap-filling was achieved after ten days to a fortnight from planting in all the experiments.

A simple experiment was laid down at Serere in 1940–41 in twelve random pairs of plots, control and filled. The original stand in the twelve blocks varied from 83% down to 65%, but as the pairs of plots within each block showed good agreement between themselves no attempt was made to standardise the stand, and the requisite plots were filled as they stood. The filled plots gave $4\frac{1}{2}\%$ less yield, but the difference was not significant :—

	Total Seed Cotton : lb. per acre.	*Ginning Percentage.*
Control	1,109	29·5
Filled	1,059	29·9
Significant Difference	none	0·4

[1] MacDonald, D., Fielding, W. L. and Ruston, D. F., Empire Cotton Growing Corporation, *Progress Reports from Experiment Stations*, Season 1938–39 (1940), pp. 23–24.

There was a significant increase in ginning percentage, as is usual with greater population density, but this, of course, was not enough to offset the loss in yield.

The main series of experiments was started in the following year and was designed to take into account wide differences in the original stand, which were artificially created by random process, and also different numbers of plants per hole, since Uganda thinning practice is not stabilised in this respect. The experiments contributed considerably to our knowledge of this latter effect, but it is considered here only in its bearing on gap-filling. The design adopted throughout was a 6×6 quasi-Latin square for $3\times3\times2$ treatments, the plots being broadly rectangular in shape and from 1/70th to 1/50th of an acre in size, according to the land available. The experiments were continued for three years at Ngetta, but failed twice at Serere; in the second year because rainfall did not permit the establishment of a satisfactory original stand, and in the third year because the land available was infested with Buganda couch grass (*Digitaria scalarum*).

TOTAL SEED COTTON: LB. PER ACRE.

	Serere, 1941–42.	*Ngetta* 1941–42.	*Ngetta*, 1942–43.	*Ngetta*, 1943–44.	*Four Expts Combined.*
STAND: Best possible	516(83)	560(85)	693(72)	644(86)	597
First reduction	520(70)	597(60)	645(60)	625(80)	593
Extreme reduction	458(50)	564(40)	679(40)	662(60)	584
Significant Difference	linear	none	none	none	none
PLANTS PER HOLE: One	488	611	652	650	597
Two	503	581	684	621	591
Three	503	529	681	659	587
Significant Difference	none	linear	none	none	none
GAP-FILLING: Control	480	576	662	644	585
Filled	517	572	683	643	598
Significant Difference	none	none	none	none	none

The figures in parenthesis in the first part of the table indicate the percentage stand employed, as determined by or related to the immediate conditions of each experiment. Since they vary, the corresponding yield combinations in the last column are somewhat arbitrary. It was unfortunate perhaps that the yield levels of the four experiments were so much alike. Conclusions based on a wide range of yield would have been more convincing, although the preliminary experiment at Serere did contribute information at a much higher yield level.

There were no interactions of any importance between the different effects, so that two-way tables are not given. Of the various negative conclusions implied by this the most interesting is that there was no more tendency for gap-filling to be successful in the reduced stands than in the normal stands.

The basic spacing adopted throughout all the experiments was 3 ft. by 1 ft. This is recommended in all parts of Uganda, and is now tolerably well achieved. That it is well sufficient is illustrated

by the fact that yield suffered on account of stand on only one occasion (50% stand at Serere in 1941–42). The general conclusion reached from these experiments, therefore, is that, although it may be desirable to aim at the best possible stand at the original planting, gap-filling does not pay, and even an appreciable percentage of gaps can be regarded with complacency.

The only doubt remaining is how far the conditions of our experiment stations represent those of native practice. In general *Lygus* damage, from whatever cause, is much more severe at the experiment stations than in native plots. In all three Ngetta experiments growth was of the " raspberry cane " type which is characteristic of the effect of this insect. The preliminary experiment at Serere, however, was more normal, and growth in the 1941–42 experiment at Serere was irregular and on the whole rather stunted.

It seems safe to conclude therefore that the short-grass areas of Uganda have repeated the results at Barberton. Two questions remain :—(*a*) the effect of gap-filling in the long-grass areas ; (*b*) the effect, in the event of a thoroughly bad stand, of complete replanting as compared with gap-filling. As this alternative is hardly likely to make any appeal in practice, it is of academic interest only.

For the experiments at Ngetta I am indebted to those officers who have held the post of Agricultural Officer at Lira and Farm Manager at Ngetta.

TANGANYIKA TERRITORY.

UKIRIGURU EXPERIMENT STATION.

PROGRESS REPORT FOR THE SEASON 1943-44

BY

J. E. PEAT.

Introductory Statement.

The past season, though better than the previous one, has been the second of two very dry seasons in the Lake Province. The planting months were especially difficult. In the middle and south of the Province most of what cotton there was, was late planted : there was very considerable reduction in acreage. Following on the dry previous season, there were fears of food shortages or even famine. Actually, mainly probably as a result of good April rains, the millet (sorghum) harvest was good : the cotton crop in the middle and south of the Province was very light, but it was good around the Lake.

These last two difficult years have helped to direct attention to the fundamental agricultural problems of the Province, those concerning soil erosion and soil exhaustion. There is increasing appreciation of what is involved. The most likely approach seems to be the throwing of land out of cultivation for resting periods under some sort of grass ley, grazed by stock either for the final period as with elephant grass, or for the greater part of the ley as with other perennial grasses. In the flat areas with friable soils where ridge cultivation is not practised and where erosion is to be feared as much as, or more than direct loss of fertility, this " alternate husbandry " might take the form of strip resting and cropping.

One of the most important functions of these stations, Ukiriguru and Lubaga, and their satellite plots, must be to test out possible methods of this " alternate husbandry," and to get some assessment of the benefits involved. On all the evidence available the grass rotation suitably grazed seems to give the greatest promise for the improvement required ; but action must await, as a first preliminary, the results of, and evidence from, investigation. Even when confident of what is required and what benefit is to be expected, the practical application over thousands of square miles of territory with hundreds of thousands of cultivators must be for those concerned an immense, almost a staggering, undertaking requiring every assistance possible from everybody concerned. But these problems of erosion, and soil exhaustion through continuous cropping, have to be faced.

The holding of soil from erosion, and the maintenance and raising of the level of fertility, must affect the whole economic life of the Province of which cotton-growing is an integral part. The experience of the last period of years has shown that, given jassid-resistance, cotton is the cash crop of predominant importance in the Province.

Rice, valuable as a food, has a value as a cash crop in wet years, but in much of the Province is a failure in dry years. Chick pea (*Cicer arietinum*), if market conditions allow, should in most years be a valuable source of revenue, but as far as can be seen much of the cash economy of the Province must be built around stock, cattle products, and cotton. Any shift over to "alternate husbandry," while benefitting the soil, it is hoped, would also improve the amount and quality of the grazing, all making for an incomparably sounder agriculture than exists at present.

Cotton selection work towards the production of a better strain continues favourably. This is, after jassid resistance, the second requirement in the creation of a more stable cotton industry. A range of the best selections from Lubaga and Ukiriguru is now being tested, preparatory to the future centreing of the work at Ukiriguru. It seems safe to say that in the present selected material there is a strain to replace Mz.561, combining good jassid-resistance, yield, vigour, a reasonable ginning percentage, and lint quality. It is a matter of getting the best combination of the characters desired : the assessment awaits trial results and lint reports. It seems most likely that the next big advance will be from locally-selected strains from hybrid material from Barberton.

A fair amount of the energies at Ukiriguru are taken up with development and the making of a Station, especially difficult under war conditions.

Agricultural Circumstances.

Weather.—The Ukiriguru rainfall for the period November 1st–June 30th, the "crop season," was 20·15 inches. The planting conditions were bad, 2·49 inches in the period November, December, and under 9 inches in the next three months. This was especially difficult following on the drought of the previous season. Crops were established with difficulty and mostly late. As a result, the acreage planted to cotton in the middle and south of the Province was small. (In contrast, the planting rains this season have been excellent ; a large acreage in the Province has been planted to cotton.) The $7\frac{1}{2}$ inches fall in April filled out the millet and sorghum crops, in spite of early season forebodings, but it came too late for maize, which was poor. The heavy April rainfall was probably responsible for the considerable jassid damage that occurred in parts, although the year as a whole was a dry one.

Soils.—Crops were very much more easily established on the light upper soils than on the heavy bottom "mbuga" types. The light showers there were sufficient only to germinate the seed, but there was not enough moisture to allow of the establishment of the crop. Repeated replantings were made until for some crops seed was exhausted ; and with some of the longer-maturing sorghums the time came when it was too late in the season to be worth while replanting further.

Cotton was not well established in the Ukiriguru " mbuga " until early February. The trial yields for Mz.561 were around 500 lb. per acre but 65% was Grade C. The cotton on the upper sandy lands was well established by the end of December to the beginning of January ; yields were similar to those on the " mbuga," but the percentage of Grade C was under 15%.

All this points a lesson. The bottom soil types are rich, but agriculturally are tricky to handle in years of light planting rains and in wet years. The upper lighter range of soils are safer, and worth protecting. It is these upper soils which require building up and protecting from erosion.

Agricultural System and Native Agricultural Practices.

Fertility.—The droughts of the past two years, with the fears of famine they caused, have directed greater attention to the dangers resulting from the exhaustion of the more easily cultivable soils in the Province. It is being realised generally that action must be taken, but exact information is a necessary preliminary to action.

In the lighter soil areas, in spite of pressure, manuring is indifferently practised. The quality of the manure is low and there is little inclination to make proper use of what is available. The Senior Agricultural Officer, Mwanza, in his monthly report for September, 1944, has said : " An occasional plot of manured land may now be seen in the areas where manuring is receiving encouragement. It, however, becomes more and more obvious that with the use of dung for fuel, and at the low rate of manure making per beast, the total amount of manure which can be made in the Province is *utterly inadequate to the needs.*"

There is to all intents and purposes no conscious rotation of cotton and grain.

Every effort must be made, however, to extend the use of manure and the practice of rotation. The Ukiriguru manurial-rotation trials this past season have not been very satisfactory. Owing to the light rains, plot stands, especially in the cotton plots, were patchy, and there were difficulties in refilling. The second-year manurial and rotation trial was planted to maize, and on the lighter lands maize suffered in the drought.

1943–44 Manurial Trial : Millet.

	Mean Yield lb. per acre.		
	Total Trial. 12 Replications.	*Block 1. 6 Replications.*	*Block 2. 6 Replications.*
Cotton-seed ash, 3 tons per acre	1,359	1,172	1,549
Compost, 7 tons per acre	1,357	1,189	1,527
Farm Yard Manure, 7 tons per acre	1,261	1,174	1,352
Farm Yard Manure, 3 tons per acre	1,178	1,000	1,358
Compost, 3 tons per acre	1,076	908	1,246
Control	1,032	801	1,164
Least significant differences P=·05	145	154	226

These millet yields are high. This result is due partly to its having been a good year for millet ; at the same time it is likely that the tieing of the ridges in holding rain helped. The deep ridging practised at Ukiriguru, bringing up nutrients and the finer soil particles, probably helped also. In the same way the levelling of the areas of old, native cultivation for experimental use actually seems to have helped the first crops growing there, probably by this bringing up of nutrients and the finer soil particles. The high level of yields on the second block of six replications might be explained in this way ; it was a newer area of land than the other and carrying its first proper crop since the levelling.

The benefit from the application of cotton-seed ash is greater than expected. 3 tons per acre is a heavy dressing, but it was not expected that yields as good as those following 7 tons per acre of good farmyard manure and compost would be reaped. In this season's experiments the dressing has been reduced to 1½ tons per acre. These results raise the possibility of adding nutrients to these sandy soils over and above any improvement of soil structure and humus content. There is a great deal of simple soil work required in these areas, with chemical analyses and soil examination.

There was a suggestion this year, with cotton following maize in the third year of the 1941–42 manurial trial, that the cotton following maize following cotton was poorer than the cotton following maize following grain. In other words that last year's better maize crop (page 114, 1942–43 Report) following cotton in the rotation, as compared to two years grain, had affected this year's crop. The mean yields for Control were 780 and 920 lb. seed-cotton per acre (the comparable mean maize yields last year for Control were 1,440 and 1,140 lb. per acre).

It is known that the amount of manure the ordinary cultivator can make is small, even with a covered yard and the wish to make as much manure as possible. His wastes for bedding are limited. At Ukiriguru, in the dry season, bedding-down oxen at nights with ample bedding, but working them and allowing them to graze during the day, manure at the rate of only 2 tons per beast per year was made. Keeping them in night and day, and feeding in the covered yard, increased the rate to 3 tons per beast per year. An ordinary cultivator with, say, 5 head of cattle and keen on using manure, would have difficulty in making as much as 7 tons per year ; even this would be inadequate to his needs. The great majority of the cultivators have available only a fraction of this amount.

Alternate Husbandry.—In these areas there are two aspects of the grass rotation which require, probably, different emphasis for the different soil types. It is difficult to generalise for the large range of soil types. By building soil structure it is hoped to achieve a reduction of erosion on the more friable, more easily erodible, soils. This would be of especial importance, for example, for the " ibushi " soils of

Shinyanga, such as those at Lubaga. The second aspect is the improving of fertility. As has been mentioned previously, there are doubts about the structure-forming value of a grass rest on soils low in binding material—for example, such soils as the Ukiriguru hill sands, which are sadly deficient in humus. Here, possibly, the additional value of the ley will be in its being grazed. The soils of a large part of the Province, however, should have sufficient colloid to benefit directly from structure improvement.

The first two resting trials at Ukiriguru are being dug in this season : these are on hill sand. Most of the treatments have been grazed down during the dry season. The variants comprise, in the one trial, different treatments of elephant grass against millet Controls, and, in the other trial, a comparison of the possible benefits from a period of three years under elephant grass, *Hyparrhenia dissoluta*, *Cynodon plectostachyum*, and pigeon pea, against the controls—continuous cotton and continuous millet. Further trials embodying improvements in layout were laid down, one trial two years ago and one trial last year.

Under these conditions and with droughty seasons elephant grass will not stand up to grazing and cutting. Therefore the obvious next step has been the laying down of plots of the more likely local perennial grasses—in fact mainly those that have established themselves in drains or are coming in to land left to natural fallow. Around Ukiriguru the native lands, the sandy and light hill lands, have been cropped continuously for a long period of years, during which time very little has been returned to them. There is never much hill grazing, and that is hard used. If land were abandoned to natural fallow the indications are that in time the better perennial grasses would return, but it would probably take 15–20 years for them to cover the ground. Any attempt at establishing these grasses in resting land would require, at least for a start, seeding or the introduction of root material.

Cenchrus ciliaris, which shows promise at Lubaga, is possibly useful at Ukiriguru, but the two which show most promise are *Brachiaria brizantha* and a *Panicum* (*longubatum ?*).

Pigeon pea has not been altogether happy in the last two droughty years, and after two years in the trials, stands were greatly reduced by white ant damage and by plants dying off. None of the other legumes tried seems satisfactory as a resting cover.

General Farm Activities.

The farm activities continue as mentioned in earlier reports : they include the seed farm work ; the multiplication and testing of early-maturing food crops, mainly sorghums, for use in countering food shortages ; and observations on *Striga helmonthica*. Some indication of how serious this parasite can be on the heavier lands

is shown by a comparison of the yields in the *Striga* observation plots : the Control plots, now heavily infested with *Striga helmonthica*, yielded around 120 lb. per acre of sorghum ; the yields, in the plots adjoining following cotton, where *Striga* was not a factor, were more than ten times this. A clean-weeding experiment should this year give a more definite measure of the loss involved. The cotton rotation benefit on the " mbuga " is also under trial.

At Mwabagole Rice Station there was pump trouble and no natural flooding. The strain tests were therefore under conditions of water deficiency. In the trials the best selection showed a 50% improvement in yield over the control (Afaa Mwanza) in the one trial, and over 100% improvement in the other. There is scope for improvement by selection. The trial on the digging-in of green material was ruined by the lack of water.

Cotton.

Spacing.—The results from fifteen district plots show agreement with the general conclusions of other years. The spacing generally recommended, 2 rows per 5 feet ridge × 12 inches × 2 plants per hill, seems a wise one. On the poorer soils, with late planting, any marked increase in the spacing reduced yields. On the Lake shore, with earlier planting under better conditions there is little drop in yield until a wide spacing is reached, such as 1 row per ridge × 24 inches × 2 plants per hill.

Selection and Testing.—At Ukiriguru there were two strain trials on the hill soil and one on the " mbuga," and there were trials at the fifteen district plots scattered throughout the Province (excluding Shinyanga) ; yields varied from around 300 lb. to 1,300 lb. seed-cotton per acre. It was where planting was late and/or conditions difficult because of drought or pests, that the greatest differences showed up. Around the Lake shore, with little pest trouble and better rains, there was little difference in yield between the strains tested. It is much easier to breed for yield improvement for difficult conditions than for easy conditions.

Under the easier conditions there was no difference in yield between Mz.561 and " Local," which it is superseding. Even at Ukiriguru in the hill trials, with yields on the 500–700 lb. per acre level and severe jassid attack, there were no significant differences in yield between Mz.561 and " Local." But in the " mbuga " trial, which was not properly established until early February, Mz.561 yielded around 30% better than " Local " ; and again in these district plots where planting was late and conditions difficult, Mz.561 was the better variety. There is little difference in their spinning performance. Mz.561 has only fair jassid-resistance, and the sooner it can be replaced by an improved strain the better. The best selected strain yielded 20% better than Mz.561 in the one Ukiriguru hill trial, and a strain

of high jassid-resistance 25% better in the other. In the "mbuga" trial, MU8A yielded 100% better than "Local" (766 lb. to 381 lb. per acre) and over 50% better than Mz.561.

It should be safe to say that in the present selected material there is a strain combining the qualities desired to replace Mz.561. It is a matter of testing for both field and spinning qualities.

Preparatory to the centreing of the Province cotton work at Ukiriguru, trials of the best Ukirguru and Lubaga strains are being conducted at the stations and in this season's district plots.

Of the Uganda strains tried only the BP.50 lots have enough jassid-resistance to come into the picture: last season the Gatooma selection 9/278 yielded disappointingly in the trials; this year BP.50S6 (a Uganda selection from the same family) which combines jassid-resistance and high lint quality, has tended to yield below Mz.561 in the trials. This is especially unfortunate as they are markedly superior to "Local" and Mz.561 in spinning qualities.

Cotton Pests.

Jassid.—In spite of its being a dry year, jassid damage was severe on Ukiriguru and in other areas in the Province. As usual there was considerably less, to almost no, damage on the cotton on the Lake shore fringe. The severity of the attack may be attributed to the heavy April rains; heavy jassid damage is normally associated with wet seasons. A high degree of jassid-resistance is essential; that is the first pre-requisite in the selection work. In the one trial on the hill, heavily damaged by jassid, O/16, a highly jassid-resistant selection from Mz.561, but not a particularly efficient cropper, yielded 25% more than Mz.561; and in the "mbuga" trial MU8A was 100% better than "Local" and 50% better than Mz.561; this would be accounted for partly by the magnificent jassid-resistance of MU8A.

Stainers and Calidea.—Generally, the later the crop the more the chance of stainer damage. The amount of staining as measured by the percentage of Grade C from the crop picked—a method only partially satisfactory—was higher this year at Ukiriguru than in most seasons. For the hill trials it was around 16%, and for the "mbuga" trial it was around 65%, a figure more in line with some of the Lubaga figures. As far as cotton is concerned, one of the major differences between the country served by Lubaga and that served by Ukiriguru is the amount of stainer damage. The early populations of stainers at Ukiriguru were mainly *D. superstitiosus* and *D. nigrofasciatus*, but by mid-June, especially in the "mbuga" cotton, there were fair numbers of *D. fasciatus*. There were no population counts.

In the district plots the percentage of Grade C was low near the Lake, in one plot as low as 1%, but it was higher inland where, in one bad plot, it was as high as 55%, and in another, near Ukiriguru, around 30%.

In the resting crop trial where there were eight blocks of cotton separated by blocks of millet, half were treated with sodium arsenite following the practice worked out at Lubaga. The cotton was " Local " ; it suffered jassid damage, and as the plots were controls in the trial, growth was on the small side. But the plots were a fair representation of the better-tended native cotton in the area on similar exhausted soil ; the yield was around 260 lb. seed-cotton per acre. There was no improvement in yield as a result of the treatment, nor any difference in the percentage of Grade C—around 12%. The treated plots suffered from aphis attack throughout the season.

Arrangements have been made this season to treat bigger-growing cotton in the " mbuga."

Capsid-Lygus.—There was no noticeable *Lygus* damage on Ukiriguru. There were reports of mild *Lygus* damage in Ukerewe and Uzinza, but these areas could not be visited this year.

American Bollworm.—There was a small American bollworm attack at Ukiriguru in February. As before, it is most likely of the farm's own breeding—bred probably from pigeon pea that was not ratooned because of the drought. There were reports of American bollworm loss from some of the district plots.

Aphis.—Aphis was again troublesome on the young cotton at Ukiriguru.

PROGRAMME FOR 1944-45,

The programme is a continuation of the lines of work already in hand.

The manurial, rotation, resting crop and grass ley work continues. Blocks of the most likely local perennial grasses are being grown. The two resting crop trials planted in the 1941–42 season are being dug in, and are being planted for the first year to a mixture of millet and Wiru sorghum.

Cotton selection goes on. The best strains from Ukiriguru and Lubaga are being tested, with replications in the scattered district plots. Some lots from Parnell's U.4 × Sea Island crosses are being grown with the keenest anticipation.

The other farm activities continue. The early-maturing varieties of sorghum, including the three Swaziland strains, are being tested in trials at Ukiriguru and at the district plots.

LUBAGA EXPERIMENT STATION, SHINYANGA.

PROGRESS REPORT FOR THE SEASON 1943-44

BY

A. N. PRENTICE.

PART I.

Introductory Statement.

This Introduction is supplementary to that of the 1941–42 Report, and deals more particularly with such differences as exist between Shinyanga, served by Lubaga, and the rest of the Lake Province served by Ukiriguru. Viewed synoptically, Shinyanga fits naturally into the main cotton belt of the Province ; viewed in detail, Shinyanga shows some differences. Although these differences are naturally the concern of Lubaga, it should be clearly realized that very much of what is written in Ukiriguru reports applies as well to Shinyanga District as to the several other much larger Districts[1] which form the nominal confines of the Ukiriguru beat.

Soils.—The problems arising from pressure of population on the land—basically problems of soil fertility—are common to the whole Province ; but very broadly the soils of the cotton-growing areas are heavier in the south (*i.e.*, Shinyanga) than elsewhere. Consequently the emphasis in the south shifts more to the soil-structure side of fertility problems. This is not to minimize the importance of other aspects of fertility, but the most hopeful immediate approach to the problem of maintaining or improving yields in Shinyanga does seem to lie along the lines indicated, for instance, by the soil-structure work of Dr. W. S. Martin in Uganda. Investigations on grasses and resting-crops generally, and their effect on crumb-structure, have become increasingly important in the Lubaga programme in recent years ; not original work so much as a checking of results from elsewhere under local conditions and with local materials. The first stage, observation, has shown justification for elaborating this work. Experimental results will not be available for some years, but present indications are that " the current panacea of mixed farming " is certainly not enough in itself to maintain the local soil in condition, and it may well be that the roots of the fertility problem lie literally under a grass rotation. The crumb-structure of the black loam soil of Lubaga is probably capable of appreciable improvement : preliminary samples examined by Dr. Martin (1943) show at their best only 25 % water-stable crumbs over 0·5 mm.

The heavier soils of Shinyanga (which produce at least 75 % of the district's cotton crop) can be classified into two main types, the friable

[1] The political division " District " may convey the wrong idea of size to those unacquainted with Africa. Shinyanga, for instance, although one of the smaller Districts and occupying barely one-hundredth of Tanganyika, is nearly half the size of Wales.

black loam known as " ibushi " and the heavy black cracking soils of sluggish drainage sites known as " mbugas." Both soils are of good inherent fertility, and both are well on the alkaline side of neutrality. " Ibushi " on the geological map traces to Plio-Pleistocene " calcareous lacustrine deposits," and the " mbugas " are essentially alluvial clays still being deposited.

" Ibushi," the soil of Lubaga, has many agricultural virtues, but it is often a soil on the shallow side ; it powders quickly (its native name means " dusty soil ") under cultivation or overstocking, and suffers badly from erosion by wind and water ; consequently its sheer retention is the prime necessity, and this lies behind the direction of much of the work on Lubaga, work on points such as the immediate effectiveness of tie-ridging in holding soil and water *in situ*, in addition to the grass-rotation investigations. " Ibushi " is a very popular soil in the district and if any area is opened up by the provision of water supplies—water supplies are poor over nearly all such areas—it is quickly populated. One very large area in the south-east of the district, now in the process of being settled around " tank-dam " water supplies, has come under the joint watch of the Agricultural, Veterinary and Forestry Departments, and all known practicable measures to avoid deterioration are being or are about to be enforced on this good but sensitive soil. This area, centred some 40 miles from Lubaga, is already an important cotton producer, and can become and remain very important. Lubaga findings are doubtless applicable to the area, soil and climate being similar, but a 4½-acre experiment plot, which can also serve for demonstration, has been established there for greater certainty. The one obvious difference from the Lubaga area is the absence of the baobab, an important host of the stainer *D. fasciatus*, and in the new area that particular pest should be less of a burden to cotton-growing than elsewhere in Shinyanga.

The " mbuga " areas, so far as Lubaga is concerned, have not received a great deal of experimental attention, but here, again, a 4½-acre experiment plot has been started in the district. The " ibushi " soil, a unique type, is virtually confined to Shinyanga district, whereas " mbugas " are found in many other districts. The eventual " taming of the ' mbugas '," those great areas of seasonally swampy grassland, will doubtless involve heroic measures outside the experimental scope of a station such as Lubaga. But although not much will be found in Lubaga reports about the " mbugas," they are very important, if not very reliable, contributors to the cotton output of Shinyanga.

One other of the heavier soils of the district deserves mention, as it is now coming under experiment. This soil, known as " ibambasi hardpan," although by no means confined to the district, is important in extent in Shinyanga and yet is the least occupied of all soil types. " Ibambasi " seems to be related to " ibushi," but as might be gathered from the term " hardpan," this " ibambasi " has very difficult physical properties—hence its unpopularity with the hand-hoeing cultivator—although it can, on occasion, produce good crops, and its

nutrient status is satisfactory.[1] Practicable methods of ameliorating this hardpan soil might help the maldistribution of population in Shinyanga and ease the strain on other soils ; a start has been made on testing possible methods,[2] hence the appearance of the subject in Lubaga Reports.

Pests of Cotton.—Of the specifically cotton problems, that of insect pests takes first place in Shinyanga. Everything that is written in Ukiriguru reports about jassid applies as well to Shinyanga as to the rest of the Province. The breeding for jassid-resistance at Lubaga follows the same lines as at Ukiriguru, the work here being in fact an extension of that at Ukiriguru ; and naturally there is much interchange of material between the two Stations. The bollworms, American and Spiny, seem to be of about equal importance in the two areas. Where Shinyanga does diverge from the rest of the Province is in the greater intensity of its stainer attack. The difference is one of degree, but an important degree, and it accounts for the high place given in Lubaga reports to investigations on stainers. On the whole Shinyanga falls naturally into the Lake Province, but bordering as it does the adjacent Western Province, it acts as a buffer district between the two and takes what might be called the insect back-wash from this Western Province. In the neighbourhood of the Provincial boundary the vegetation changes fairly abruptly, and this change seems to influence the cotton pest position very much for the worse in the Western Province. The cotton history of the Western Province, where strenuous attempts were made to foster the crop in the 'thirties, is one of failure due to insect pests, particularly those stainers (*Dysdercus* spp. and *Calidea* sp.) which are the main pests of Shinyanga cotton.[3] The sub-area of Shinyanga actually bordering the Western Province has been excluded from commercial cotton-growing since 1941, on account of the excessive pest-damage.[4] In regard to two other insects, Shinyanga differs from (parts of) the rest of the Lake Province : capsid and pink bollworm are nowhere pests in Shinyanga.

The Place of Cotton in the Native Agricultural System.—What has been said on this subject in Ukiriguru Reports again carries equal weight for Shinyanga. Cotton is still a crop apart, but it is not unpopular nowadays, and a gentle braking has had to be applied to its planting in the past season or two when there was a potential (and unfortunately realized) shortage of food. Cotton is the main source of cash for the masses in the cotton areas, and no other crop seems likely

[1] On " quick-test " results by Dr. W. S. Martin of Uganda.

[2] Methods based on suggestions by the late G. Milne, of Amani, in his " Soil Reconnaissance Journey " (unpublished). Milne says of *ibambasi*, " The bringing of these neglected, because somewhat intractable, hard-pan soils into the agricultural picture may perhaps be a policy of the future—but inevitable and not very distant. The problems involved, because they may take a long time to bring to effective solution, are best regarded not as problems of the future, but of the actual present."

[3] Information condensed from that supplied by the Senior Entomologist, Mr. W. V. Harris.

[4] Mr. Bebbington's investigation in 1940 showed that this sub-area contains numerous stainer host plants.

to compete with it. Shinyanga, so far as can be foreseen, will always remain an agricultural area. Two diamond mines have recently developed in a large way in the district, but they can divert only a small fraction of the people from the land, although they may have some effect in providing an outlet for local produce.

General Account of the Work of Season 1943–44.

Inherent Agricultural Circumstances.

Weather.—The season's rainfall at Lubaga was 25·09 inches, well below average. The rains started exceptionally late and finished exceptionally early, and the distribution was bad. On Lubaga, the four heaviest falls of the season accounted for over 40% of the total rainfall. Rainfall in the cotton-growing areas of the district was equally bad.

The district crops suffered accordingly ; yields were very variable but poor on the whole. Food crops, in spite of a greatly increased acreage, will not provide enough for the needs of the district, and food will again need to be imported. The cotton crop suffered from the weather : directly, through late planting, and through poor rains leading to patchy germination and bad stands ; and indirectly, through partial or complete abandonment of much of the acreage when the deteriorating food situation and the threat of locusts diverted still more of the cultivators' time into enlarging the already extensive acreage of food crops. The cotton acreage at the outset was probably bigger than that of last year ; the cotton crop, far and away the worst for a decade, may finish at around 750 bales. The other cash crops, groundnuts and rice, were very poor indeed. By contrast the Lubaga crops were very good.

Soils. " Ibambasi " hardpan soil.—An investigation into ways of management of this soil-type has been started on Lubaga.[1] Although the soil of Lubaga is mostly the black loam, there are several acres of the hardpan soil known as " ibambasi " on its border ; that this soil forms a perfect natural aerodrome for Shinyanga may give some idea of its surface qualities. A heavy two-disc plough can normally do little more than scratch the surface. The grass-cover is scanty, but this soil does not seem to suffer from erosion on over-grazing, as does in extreme degree the black loam. " The real risk is intensified agriculture."[2] A range of crops, including grasses, is being tried on

[1] Milne, *loc. cit.*, says, " If field experimental work were undertaken (as it certainly should be) towards the reclamation of *ibambasi* where it is an extensive and potentially important type "—as it certainly is in Shinyanga—he would like to see tried " Trench drainage to encourage leaching, gypsum dressings, high ridging for all crops, and heavy composting ; with, of course, deep sub-soiling to begin with, and the necessary anti-erosion lay-out of the site." These treatments have been followed in the present Lubaga experiment, with some modifications : gypsum is unobtainable, the ridges are tied, and the sub-soiling that was finally accomplished was anything but deep.

[2] Milne, *loc. cit.*

the Lubaga "ibambasi" in observation plots. The crops in the experiment proper are confined to cotton and sorghum, virtually (with the specialized exception of rice) the only two crops grown by the cultivator in the areas where he does perforce use this hardpan soil.

There are at least six sub-types of this "ibambasi" hardpan known to the natives of Shinyanga, and distinguished by the vegetation; one, extreme, is so cement-like that it is never used under any consideration, but the others, including the type on Lubaga, are used to some extent and are said to grow "softer" under cultivation. The Lubaga experiment was not expected to show much in the way of results the first season, but in spite of very late planting, the difference in favour of tie-ridged over flat cultivation was spectacular. In the one prolonged wet spell in mid-season, however, the tie-ridged plots showed very obvious depression in growth due to waterlogging; and although they much more than made it up after the rains had stopped, continuing to grow well for two months after the "flat" plots had shut down completely, the water-balance is obviously very tricky on "ibambasi" soil. The heavy manuring (10 tons compost per acre) gave some small increase in growth over the controls, just visible to the eye on both crops, but with the flat treatment seemingly deriving appreciably more benefit (relatively) from the manuring than the tie-ridged treatment. The observation plots (under some of the same treatments) showed the same general trends, with the one exception that a *Tephrosia* from Ukiriguru seemed to grow as well on the flat as on the tie-ridges.

The Agricultural System.

Grass-rotation Work.—The bearing of this work on the soil-fertility problems of Shinyanga is outlined in the Introductory Statement.

The 1943 dry season was a very protracted one. Elephant grass stood the long drought fairly well, but suffered moderately heavy loss of stand. The perennial Kavirondo sorghum, however, mentioned in previous Lubaga reports as being able to withstand the dry season, this time died out. The indigenous grass, *Cenchrus ciliaris*, came through the test very well. None of the other grasses tried was able to maintain itself above ground, although a few such as *Hyparrhenia rufa* and couch-grass came away virtually from underground with the rains. The search for other grasses will continue, but elephant grass and the *Cenchrus* are at the moment far and away the most promising stocks on Lubaga, and both are now in resting-crop trials. These trials will take several years to run their course. There was difficulty in establishing *Cenchrus ciliaris* from seed this year; only a start has been made towards a knowledge of the best ways of handling and using this grass, but such investigations are running parallel to the trials whose main function it is to assess the recuperative and soil-conservation powers of the resting-crops.

Two small fields of two-year-old elephant grass came under cotton this season. The fields showed a satisfactory structure of the soil

on ploughing, and gave good growth of cotton ; but as there were no controls, the statement that the results were promising must be accepted with reserve, as subjective.

Elephant grass was planted widely on the farm, and was established with moderate success in spite of the very difficult " wet " season. This grass, and/or *Cenchrus*, will continue to be planted yearly, a corresponding acreage coming back into cultivation every year once this alternate husbandry system gets into its stride. Details, such as the length of time the land will be under grass, will be adjusted from the experience of the *ad hoc* trials now under way. The adoption of a grass rotation by Lubaga is a step, if not in the dark, then in the encouraging half-light ; at the worst, fertility will be left unchanged, at the anticipated best, some years will have been saved in starting to " renovate " the soil of the farm.

The red-soil extension to Lubaga, known as Butulwa, has a simple trial of continuous cultivation *versus* rest under elephant grass for three years followed by cultivation for (probably) three years. This red loam soil, incidentally, would hardly come under the agricultural classification heavy, but it is a soil of more body than the other granitic derivatives in the district. The bulk of Butulwa, 12 acres, is now down to 2-acre strips of elephant grass and annual crop, to give field-scale experience of a strip-cropping system borrowed from Uganda. The stand of elephant grass on the red soil was very poor this year, as a start, and it is now in the dry season being still further reduced by game ; but the object of the block is to discover such snags at an early stage.

Agricultural Practices.

Tie-ridging ; Manuring.—The sorghum yields on Lubaga, in contrast to most of those in the district, were as good as or better than any in the past five years. The heaviest sorghum variety in fair-sized trial plots was yielding 2,600 lb. grain per acre, and the same variety (Nzanza) in bulk also yielded very well. The heaviest cotton strain trial on Lubaga averaged 611 lb. seed-cotton to the acre, and about half of the cotton on Lubaga showed yields of the same order, satisfactory yields for the enforced late planting (January, mostly) of the year.

The success of the Lubaga crops this season was almost certainly mainly due to tie-ridging. All the annual crops on the farm were tie-ridged this year. The evidence from trials on the farm, although not all of it was strictly applicable to the conditions of the bulk crops, left no reasonable doubt that tie-ridging played a vastly more important part than manuring in determining yields this year. The reason for the very striking increases in yield from the tie-ridging (compared with flat cultivation) was fairly obviously the high efficiency of tie-ridging in holding all the rain within root-reach of where it fell ; the reasons for the small responses to manure—responses of the average order of 10% improvement over nil controls—are obscure.

The District Agricultural Officer, Mr. Lunan, ran a series of paired demonstration plots of " good " and " bad " farming practices at about a dozen centres in the district. These were a success on the whole, the " good " plots giving nearly double the yield of grain of the " bad " on the average ; the treatments in the well-farmed plots were tie-ridging plus manuring, contrasted with flat cultivation and no manuring, but the respective influences of tie-ridging and manuring on yield could not be separated.

The three permanent district experiment plots of $4\frac{1}{2}$ acres each, started this year, were failures. The cultivators in charge, new to the job, got behindhand in their operations in a season which allowed no safety margin in time. Two of the three made conscientious efforts, and one on black loam soil managed to establish several good blocks of sorghum and cotton, which bore out the more exact experience on Lubaga of strain behaviour this year, and also helped to confirm the benefit of tie-ridging compared with flat cultivation. The all-important resting-crops were nowhere established however.

Cotton on the black loam this season was unresponsive to three minor elements, boron, manganese and magnesium, applied as borax, manganese dioxide and magnesium sulphate (5, 50 and 80 lb. per acre) alone or in combination, or with 5 tons per acre compost. The compost itself showed no appreciable benefit to growth or crop, and the same held for dressings of blood, bones and ash (500, 1,000 and 1,000 lb. per acre).

Miscellaneous.—Sorghum trials showed, as expected, that the yields of the very quick-maturing Swaziland types were far below those of the district stock strains. The quality of these quick sorghums is passable, however, and there is a definite place in Shinyanga for such types by virtue of their very speed. They form a useful complement to the standard heavier-yielding late types, more especially at times when a succession of bad seasons has wiped out the normal carry-over of food supplies.

An example of unpremeditated plant-introduction in Shinyanga is worth mention : a Kenya sorghum brought in as part of the food relief supplies two years ago must have been tried as seed, and it seemingly throve so well that this season it was voluntarily planted over a considerable acreage.

Cotton Breeding.

The U.4 and U.4×Cambodia stocks on Lubaga have now been fairly thoroughly combed ; generalizing, the selections are not quite up to requirements in lint quality or vigour, and selection work in the past few seasons has been increasingly concentrated on the Mwanza (Uganda Upland) stocks. This policy has given a greater proportion of selections of all-round promise. Mz. Local itself contributes to these, and Mz.561 provides the majority, as on Ukiriguru, but, as it happens, the most promising selection of all (incidentally, not a primary

selection) derives from the least important of the three main Mz. stocks, Mz.457. The best selections are exchanged with Ukiriguru every year ; conditions on the whole are so similar on the two stations that such strains are not regarded as " introductions " in the ordinary sense of the term.

The selection and testing work, important as it is, can be summarized by saying that it made good progress on the whole. The qualification is added because in one field an abnormal termite attack (mentioned under " Cotton Pests ") spoiled three important strain trials. One of these contained BP.50S6 and N.C.4. Under very heavy jassid attack the N.C.4 suffered more than BP.50S6, both types standing the attack far better than Mz.561, but both being visibly inferior to MU8A—put in as a type in the hope of just such an attack—in resistance and, of course, ultimately in crop. These periodic dangerous jassid attacks, sometimes, as this year, confined to one part of the farm, are salutary reminders that a very high standard of resistance must be continually maintained in the breeding work. The Kingolwira strain K.553 was in (successful) trials on Lubaga this season, and is worth a " negative " mention : although a successful strain in its own environment, K.553 suffered appreciably from jassid in a field where the attack was definitely light by Shinyanga standards, and yielded nearly 30% below Mz.561, the crop being almost certainly due to nothing but jassid damage on an otherwise good strain.

Cotton Pests.

Jassid.—Jassid attack was very variable on the farm, as inferred under the Cotton Breeding section, and although one field, the earliest-planted as it happened, had a very severe attack in mid-season, jassid generally was light this year. In spite of the dry season, heavy jassid was reported from parts of the district ; in at least some of these areas, however, which were inspected some little time after the reports, either the attack had been very short or the symptoms had been misinterpreted, and jassid *damage* at any rate was not heavy in the district this year.

Bollworms.—Both American (*Heliothis armigera*) and Spiny (*Earias insulana*, and doubtless also *E. biplaga*) bollworms were present but unimportant on Lubaga this season.

Termites.—Termites always do some damage to Lubaga cotton, and decimation or even a 30% loss of stand is just accepted as a minor necessary evil. (The average loss in 18 trials over the past few years has been 25%, a loss largely due to termites, and luckily nearly always spread at random.) A crippling attack this year, however, deserves to be put on record.

The stand over about 4 acres of a seemingly uniform 8-acre field of cotton was reduced from " normal " (unrecorded) to about 5% within two months of planting. Young and seemingly perfectly healthy seedlings were attacked at or below ground level and few if any

recovered. The termite responsible was identified by Mr. Harris (who inspected the field) as *Ancistrotermes latinotus* Silv., " a new record from E. Africa but known from Nyasaland where it attacks tea bushes." The remaining cotton on the farm did not suffer any unusual damage and was attacked in the ordinary way at a later, flowering stage, by termites which made earth-tunnels up the stems and did not always kill the plants. No explanation can be offered for the heavy attack. The 8-acre field, which had been treated as a unit for the past five years, had as its preceding crop composted sunnhemp ploughed under in good green-manuring condition, and judging by the growth of the remaining plants the soil was in good heart.[1]

Stainers.—It was a *Dysdercus fasciatus* year, the other three local *Dysdercus* spp. being comparatively rare ; but *fasciatus* took its usual serious toll of the cotton crop, both on Lubaga and in the district. The *Calidea* stainer attack was heavier than usual, and persisted as unusually late as August ; the damage it caused must have been considerable, both on Lubaga and in the district, but a true evaluation of *Calidea* damage has still to be made.

Experience with poisoning stainers by sodium arsenite is described in some detail in Part II ; in brief, poisoning on Lubaga has been successful enough in two seasons out of three to allow of a good crop of cotton where the controls were giving a poor crop.

SUMMARY.

The Introductory Statement deals comparatively with the background to the areas served by Ukiriguru and Lubaga ; or rather with such differences as exist and concern Lubaga, although it is emphasized throughout that both areas have very much in common, Shinyanga being in most respects just a natural part of the Lake Province whole. The two chief differences—heavier-bodied soils in Shinyanga, and more serious stainer attack on cotton—are discussed in relation to the experimental work on Lubaga.

The account of the past season's work mentions the bad rainfall and the generally bad district crops, including a very poor cotton crop ; the important part played by tie-ridging in the success of Lubaga crops ; a new Lubaga experiment on possible ways of ameliorating the hardpan soil known as " ibambasi " ; the grass-rotation work, comparatively briefly because in spite of its importance it is still very much in the early stages ; and cotton-breeding, which goes ahead steadily on orthodox lines. The insect pests of the year are reviewed fairly briefly, jassids and stainers as usual dominating the Shinyanga scene.

The only section in Part II this year records experience in controlling stainers by poisoning ; this has its own summary.

[1] Cf. remarks on termite attack in the Nyasaland 1940–41 Report, p. 160 ; and article on termite damage in Sudan cotton, by Crowther and Barlow, *Empire J. Expt. Agric.*, April, 1943.

PROGRAMME FOR 1944-45.

Unchanged from season 1943–44.

PROGRESS REPORT—PART II.

Stainer-Poisoning Experiments.

Background.—As successive Lubaga reports indicate, stainer damage is a major problem of cotton-growing in Shinyanga. Even in a year of light stainer attack—light by local standards—the loss of crop is serious, both in quantity and grade. On Lubaga the work of multiplying new selections is considerably hampered by stainers, as is testing work generally.

Dysdercus fasciatus is the most important stainer locally ; *D. cardinalis* can equal it in numbers at times, but shows great season-to-season fluctuation ; *D. superstitiosus*, at times numerous, may have an added importance because of its earliness, but the point is unproven ; *D. nigrofasciatus* is present but unimportant ; *D. intermedius* is absent, although it was wrongly given as one of the local stainers in the 1939–40 Lubaga Report. The relative importance of the stainer *Calidea dregii* var. *apicalis* is uncertain, but *Calidea* is at least under strong suspicion of being a major contributor to the damage.

Cotton-seed traps have not been very successful in reducing the numbers of *Dysdercus* in the field, and *Calidea* is not attracted to such traps. The mimic predator *Phonoctonus* does not seem to be able to control *Dysdercus* to any noticeable degree, and food supply may well be the only natural check to stainers in Shinyanga. Varying the planting date has shown little or no hope of allowing a crop to dodge stainer attack ; although it may be that there is some critical date for cotton-planting, relative to subsequent stainer attack, in practice it cannot be forecast, and other factors affecting the crop set limits to the practicable range of planting dates.

An American method of poisoning stainers was eventually tried on Lubaga. This has given satisfactory control of excessive stainer damage in two out of the past three seasons, and details are given in the following progress account.

Composition of Poison-solution and Rate of Application.—Sodium arsenate, the poison named in the descriptive bulletin, happened to be unobtainable when the method was first tried here and Mr. Harris, the Entomologist, suggested using sodium arsenite as he had found that effective against *Antestia* on coffee. (Sodium arsenite, being a locust poison, is always available in E. Africa, and this poison has been used throughout the Lubaga experiments.) One ounce of the poison and two lb. of sugar to one gallon of water form the solution.[1] This solution is applied at the rate of around 1½ gallons per acre at each application, the rate increasing to a good 2 gallons as the cotton grows bigger. The Lubaga recorders had some difficulty in striking the right rate at first, but with practice got the actual application to tally well enough with the intention. The number of applications, at weekly intervals, naturally depends on the course of stainer attack ; here the number has varied between six and nine in a season.

[1] The sweetened solution is, of course, a deadly poison. The Lubaga recorders have been strongly cautioned, and none has yet poisoned himself.

Method of "Spraying."—The poison solution is sprinkled on the plants in the form of coarse droplets by means of a short-handled mop. (A fine arsenical spray seemingly injures foliage.) The technique of slinging was soon learnt by native recorders on Lubaga. At slow walking pace the gently-dripping mop is swung forward from the pail over the left-hand row of cotton, and then back over the right-hand row before being dipped again into the pail. Two rows a side are covered in bigger cotton where there is little chance of the drops being wasted by falling on bare ground.

Results.—A start was made with two large observation blocks in 1942. This was little more than a preliminary canter. The poisoned blocks did show a reduction in the percentage of stained cotton from 61% to 34% compared with the untreated controls. Yields, however, brought very low by an intense bollworm attack, were actually in favour of the untreated blocks-at 191 lb. seed-cotton (clean plus stained) per acre, against 175 lb., although the difference could hardly have had any significance.

In 1943 the poisoning was given a more systematic trial. One member of each of three pairs of partially-isolated plots was poisoned. This time, with the yields on a fairly high place, there was no doubt of the marked benefit of the poison. The poisoned plots averaged 810 lb. per acre, of which 18% was stained, and the control plots 459 lb. of which 47% was stained. (These figures differ slightly but not essentially from those quoted briefly in the 1942–43 Report, because of subsequent corrections.)

In 1944, a more elaborate layout of seven pairs of plots again showed a very convincing reduction in the percentage of stained cotton from 44% to 6% ; and although the absolute yields were once more on a low level, for reasons not connected with the poisoning, the poison treatment yields were double those of the controls at 236 to 116 lb. per acre. Two smallish fields of cotton were also poisoned this year. In both, discounting late planting and in one case bad stand, the results were much beyond what experience would have predicted as likely under the same conditions without poisoning : one, exceptionally late planted, yielded 370 lb. per acre with 18% stained, the other, medium-late planted, gave 480 lb. per acre with under 17% stained.

These results, with other relevant details included, are tabulated on page 121.

Accuracy of Figures.—The stainer population figures in the table, taken from weekly sample records, indicate broad trends well enough—and nothing more. The accuracy of the (field) grading of the seed-cotton was tested this year, and it was found that while there is some variation between pickers, the individual is steady to his own standard ; in a crop 50% stained, for instance, the majority of pickers would grade near this, but some would drop consistently to 45% and others rise to 55% ; the average seems steady enough to justify using as refined a measure as the percentage in expressing the results in the table. The yields in the table are whole-plot or whole-field figures unless otherwise stated ; the significance of the differences in yield and grade in the two proper trials can be taken as very high, as all pairs of plots consistently gave large differences in the same direction.

Discussion.—The difference in degree of staining in the 1942 experiment was noted as doubtfully visible in the unpicked crop. In the subsequent experiments the visible difference between poisoned and control plots was very marked, in both yield and quality.

Year.	Rainfall.	Start of Poisoning.	No. of Weekly Poisonings.	Plot Size, Site, etc.	Date of Planting.	Growth, Stand, Insect Attack.	Yields and Grade Seed-cotton. Total lb. per acre.	Yields and Grade Seed-cotton. % Stained.	Treatment.
1942	April: 8·58″ (14 days) May: 0·55″ (5 days) June: 0·03″ (1 day)	3/4/42	8	Observation plots totalling $\frac{3}{8}$ acre, in bulk Field. Sample yield used.	11/12/41	Stand and growth very good. Bollworm attack intense. *Dysdercus* adults to 7,000 per acre, May; *Calidea* heavy early April.	175 191	34% 61%	Poisoned Control
1943	April: 4·36″ (14 days) May: 0·92″ (8 days) June: 0·42″ (3 days)	21/4/43	6	Six plots, *i.e.*, 3 poison, 3 control, effectively $\frac{1}{16}$ acre each. *Ad hoc* experiment, virtually a 3×2 Randomized Block trial.	23/1/43	Stand fair, growth shortish but efficient. Other insects light. *Dysdercus*, to 4,000 per acre in May; *Calidea* to 2,000 per acre in April, then dropping.	810 459	18% 47%	Poisoned Control
1944	April: 3·97″ (13 days) May: 0·32″ (3 days) June: —	18/4/44	9	Fourteen plots, effectively $\frac{1}{16}$ acre each. *Ad hoc* experiment virtually a 7×2 Randomized Block trial.	9/2/44 (*i.e. late*).	Stand bad (59% poisoned, 53% controls), growth moderate. *Dysdercus* slow rise to 2,000 per acre June; *Calidea*, sudden very heavy influx on 9/5. dropping immediately but still at 1,000 mark in mid-June.	236 116	6% 44%	Poisoned Control
		28/4/44	7	Field A, approx. 4 acres, all poisoned. No strictly compared Controls. Sample areas of better stand totalling $\frac{1}{8}$ acre used for yields.	3/3/44 (*i.e., very late*)	Progeny plots with patchy stand but fair growth. No records of insects.	480	17%	Poisoned
		15/5/44	8	Field B, 2·92 acres, all poisoned. No strictly comparable controls. 1 acre sample used for yields.	4/3/44 (*i.e., very late*)	Good stand, very short growth. No records of insects.	370	18%	Poisoned
		Not poisoned (For comparison)		Field C, adjacent to Field A (strain trial figures used).	21/1/44	Stand and growth good. No records of insects.	611	22%	(Not poisoned)
		(Not poisoned (For comparison)		Field D, bulk Field, well away from all poisoning sites.	20/1/44	Stand and growth good. *Dysdercus* over 2,000 per acre May, rising; *Calidea* over 1,000 per acre May, falling.	Approx. 300	52%	(Not poisoned)
		Not poisoned (For comparison)		Field E, a small time-of-planting trial, well away from all poisoning sites.	21/12/43 4/ 2/44 7/ 3/44	Stand patchy, growth good. No records of insects.	700 507 97	64% 60% 83%	(Not poisoned)

At the time it was thought that the practically negative 1942 result might have been due to the fact that the plots were in the middle of a large 16-acre bulk of cotton which acted as an inexhaustible reservoir of fresh stainers ; a dusk flight of *Dysdercus* has been repeatedly observed at Lubaga and it is reasonable to assume constant local movement of these stainers. In the light of later experience it seems probable that much of the poison was washed off the plants in the very wet April of 1942 ; or, another aspect of the same argument, it may have been that the stainers had so much other moisture available that they rarely had to use the poisoned droplets. a few dead stainers were found—both *Dysdercus* and *Calidea*—but many fewer than in the other years.

However, both wet weather and mass juxtaposition may have affected the 1942 result. It seems possible that the bulk poisoning of 1944 may actually have benefited adjacent untreated fields : fields D and E, both untreated, were about half a mile distant from the nearest poisoned fields, and, as the table shows, both had much more stained cotton than the other untreated field, C, this last being more nearly on a par with its adjacent poisoned field A ; to revert to the water analogy, the reservoir of the untreated field C was relatively small enough to have been partly emptied by the (problematical) suction of field A.

This supposition seems hardly to tally with the fact that the control plots in the experiments proper, in both 1943 and 1944, got and held what was adjudged a normal infestation of stainers for the season. The experimental block was, however, liable to some influx from nearby untreated bulk cotton and records[1] showed that the tendency was for the poisoned plots to fill up with *Dysdercus* stainers, between the weekly poisonings, to something approaching the numbers in control plots. (*Calidea* showed signs of behaving differently in that it did not repopulate the poisoned plots to the same extent. But *Calidea* populations fluctuate so wildly that any statements about them must be made with even greater reserve than statements about *Dysdercus* ; a sample line in one of the seven untreated plots of the 1944 trial once actually yielded 236 *Calidea*, equivalent to the fantastic population of over 40,000 per acre, and had dropped to 1 *Calidea* five days later.)

The comparative evidence from the 1944 bulk fields carries no great conviction ; but the absolute results of the bulk poisoning taken in conjunction with the experiments proper, show that poisoning is a practicable method of controlling excessive stainer damage on Lubaga.

Miscellaneous.—A casual observation in the 1943 experiment was that jassid seemed to be rather less in evidence in the poisoned plots.

An unwelcome development in 1944 was a heavy aphis attack on all poisoned cotton, doubtless due to the poisoning of aphis-predators. Untreated cotton was untouched. Aphis attack has been just accepted as much the smaller of two evils.

Foliage has never been noticeably scorched by the poison droplets.

Staining records on three-weeks-old green bolls gave some pre-indication of the grade of seed-cotton, but would need to be linked up with other crop development and loss records to provide any accurate forecast. The loc-weight of mature clean bolls was seemingly lower in the untreated than

[1] Records were taken each week on the day before and the day after poisoning, on sample lines of 1/173 acre in each of the poisoned and control plots.

in the poisoned cotton ; the observation needs checking, but if true may indicate some measure of direct damage (*e.g.*, sterile puncturing ?) by stainers.

Costs.—The cost of poisoning was tested over a measured 2·9 acre field this season. The time for any one application averaged just under 1½ man-hours per acre. Labour here is cheap, and putting it at 20/– per month, labour costs work out at approximately 1½d. per acre. Sugar is the expensive item in poisoning : at the local price of 3d. per lb., and with the poison costing, say, ¼d. an ounce, the cost of materials for a 2-gallon application (4 lb. sugar and 2 oz. poison) is just over 1/– per acre. The cost of labour plus materials for any one application can be put at a round figure of 1/2 per acre.

The market price of stained cotton is 2/6 per 100 lb. against 12/6 for clean cotton—the ratio is sometimes wider—so that a seasonal outlay of, say, 10/– per acre on poisoning, is justified commercially if anything over 100 lb. per acre of a crop can be raised from stained to clean grade. This order of change promises to be attainable on Lubaga in many seasons. The main value of poisoning at the moment, however, lies in the protection against stainer-interference that it affords to trials and to single-plant lots under multiplication.

It may be that the number of applications tried here has been either too low or unnecessarily high for best results. These and other points, such as the best time to start poisoning, have yet to be tested.

Summary and Conclusions.

1. The stainer species responsible for the serious damage to cotton in Shinyanga are briefly appraised.

2. An American method of poisoning stainers by sweetened sodium arsenite solution is described in some detail.

3. Experiences with this method on Lubaga over the past three seasons are tabulated and discussed in detail : a comparatively small and doubtful response to poisoning in the first season was possibly influenced by the heavy rains of that year, and in the more elaborate trials of the second and third seasons poisoning doubled the yields of a fair and a poor crop respectively, and greatly improved the grade ; field-scale poisoning in the third season gave satisfactory results.

4. Heavy attack by aphis on the treated cotton in 1944 may have been due to the poisoning of predators.

5. Costs of poisoning are given.

The account is essentially a progress report, and poisoning experiments are to continue, but so far as present indications go, it can be concluded that under Lubaga conditions stainer-poisoning is practicable and, except possibly in the wetter seasons, leads to a marked increase in the yield and grade of the cotton crop.

EASTERN PROVINCE.

PROGRESS REPORT FOR 1943

BY

A. G. BEBBINGTON AND A. H. McKINSTRY.

Introductory Statement.

The present Report may be said to be the first in which we can record a true beginning of detailed work on the main problems of the cotton crop in the Eastern Province.

The following is an outline of the general situation with regard to cotton-growing in the Province as shown by surveys carried out during 1941 and 1942. The major portion of the cotton-growing areas lies below the 2,000 foot contour in the coastal plain of the Territory. Ginnery returns over the period 1936 to 1942 show an annual crop varying from 15,000 to 20,000 bales, of which some 70% to 80% is native-grown, the remainder being produced on Greek and Indian estates. About three-quarters of the crop is derived from fertile alluvial soils of high moisture-retaining capacity. The remainder is produced from generally poorer and drier areas. The alluvial soils are likely to be responsible for some years to come for the major portion of the crop as there are still large areas undeveloped. The more obvious signs of soil erosion are not apparent to any extent in the cotton-growing districts. This is no doubt largely due to sparseness of population, hand cultivation and rapid regeneration of vegetation in most areas. Sheet erosion is, however, a problem of some importance on the poorer soils and in the congested areas near townships.

Climate.

The rains start in November or December and continue until May. A drought, sometimes extending over several weeks, occurs some time between January and the early part of March. The so-called " short rains " fall before this drought period and the " long rains " after it. Seasonal rainfall totals range from about 25 inches to 45 inches. There is a tendency for rainfall to be higher near the escarpment hills and on the eastern side of the mountain masses. The mean minimum temperature does not fall below 60°.

One general conclusion we have come to is that the crop is not truly raingrown. Germination and early development take place during the rains, but the main crop is set after they are over. The bulk of the crop is planted from mid-March onwards when approximately half the total rainfall is over. This conclusion is supported by the much lower yields obtained in the drier areas and the much greater adverse effect on the crop in these areas of a dry year.

Native Agricultural System.

This is greatly affected by the following factors :—

(*a*) Tsetse fly is freely distributed throughout, making cattle husbandry impossible.

(*b*) The native population is sparse, and this, together with a low standard of living, makes subsistence easy.

(*c*) Lack of diligence on the part of the cultivator.

(*d*) The existence of large sisal estates and non-native farms on which the native may work as a wage earner.

The agricultural system, if it may be so termed, is of the simplest order. Land is cultivated until poor yields or excessive weed growth compels the clearing of a new garden or return to a regenerated piece of land. The old garden reverts to a bush fallow for an indefinite period.

There are no planned rotational practices and it is usual to find the same crop grown on the same land for several successive seasons. Instances of mixed cropping are found, such as maize and pulses. Two or three different crops may be grown on the same land during one season if the rainfall distribution is suitable.

Over the greater proportion of the area soil fertility from an exhaustion point of view is not a problem.

Food Supply.

This varies considerably throughout the Province ; the staple crops, which vary considerably in the amounts in which they are grown in different districts, are rice, sorghum and beans. Maize may be considered as an important subsidiary.

Unless there should be drastic changes in population distribution or large-scale alienation of land, there would seem to be no necessity for change in the present system. That is not to admit, however, that progress in terms of increased yields per acre can be made with the present methods.

Cotton has a very essential place as a cash crop, particularly as in peace time the value of all food crops was very low. A general increase in production is limited by the sparseness of the population.

Native Agricultural Practices.

It is impossible to give any general figure for yield on account of the widely differing conditions, and more particularly, because of the damage caused by insect pest attack.

Manuring is impracticable, but, as stated, soil fertility is not a problem over the larger portion of the cotton-producing districts.

Time of planting of the crop varies considerably. March is the main month for the native planter, but according to moisture conditions planting may be prolonged into April or even May.

Spacing tends to be more or less uniform throughout at approximately three feet by three feet with theoretically two plants in each hole. Thinning is very often carried out too late or too many plants left in each hole.

Planting of cotton in an established maize crop is a fairly common practice in some districts which has been copied from the non-native estates. Its implications are very much bound up with incidence of American bollworm and it will be referred to under that head.

There is seldom any preparatory cultivation before planting, apart from scuffling off and burning of old weeds. Planting is carried out simply by making a hole with a hoe into which a handful of seed is thrown ; this is then covered with the foot. Subsequent cultivations are sufficient to keep the crop reasonably clean, but are very often late, particularly the all-important early ones.

Picking is not carried out in the most efficient manner. In the field all cotton, clean or stained, is taken together, the later grading, however, is carried out with great care. With regard to the relative attractiveness of crops other than cotton, food crops of all kinds are at present at much higher prices than in peace time and as a result cotton production has fallen steadily since the war began. Should prices fall to their previous level it is difficult to see any crop which can seriously compete with cotton.

Insect Pests.

Jassid (Empoasca spp.).—So far as our observations go this would not appear to be a serious pest of the crop under ordinary circumstances.

American Bollworm (Chloridea obsoleta).—Serious attacks of this pest were seen during the survey. It would appear that it occurs regularly, but with varying intensity, on cotton during June and July. This generation is apparently bred up on the maize crops planted in January and February.

As has been stated, interplanting of cotton in maize is fairly common in some areas. On non-native estates the cotton is usually planted a month after the maize, which practice tends to give the maximum possible larval population in the cotton crop.

Stainers.—Four species have been recorded. *D. intermedius*, *D. fasciatus*, *D. cardinalis* and *D. nigrofasciatus*. The three first named species appear to be the most important.

They occur in the crop from the commencement of flowering and severe damage may be caused to the early bolls ; very large populations have been seen towards the latter end of the season.

Pink Bollworm (Platyedra gossypiella).—This occurs throughout the Province but its importance has been greatly decreased by efficient plant sanitation methods.

Capsids.—Damage caused by these pests is common but sporadic. Our observations so far indicate that it may be a factor adversely affecting the recovery of crops previously attacked by American bollworm.

Helopeltis.—This pest is widespread, but its importance from season to season remains to be seen (1).

Spiny Bollworm (Earias spp.).—Quite large larval populations have been observed in all districts.

Stem Weevil (Apion xanthostylum).—Occasional instances of damage by this pest were seen. It has been responsible for considerable losses in the past but has been reduced to a minor status by sanitation methods (1).

Improvement of the Existing Crop.

The variety at present in cultivation is known as Eastern Province Local. It is very variable, both in plant type and for different seed-cotton characteristics. The quality of the crop is high and it has a good reputation with the markets. Improvement in yield and ginning percentage without deterioration in quality would appear to be the first consideration.

This aim is largely affected by the insect pest situation. To summarise that situation briefly the position would appear to be : the early crop is open to attack by American bollworm and stainer, the extent and period of which attack from year to year is at present unknown ; interference by Capsids, Helopeltis and Spiny bollworm at this stage is also undetermined. The middle crop may be damaged by all these pests, while the late crop is exposed to heavy attack by stainer, and, according to the thoroughness of preventive measures, pink bollworm.

The first essential is to obtain a picture of the insect situation in relation to plant development. Until this has been obtained we cannot say what type of plant is required in order to increase yield, and this forms the basis of the immediate future programme.

Programme.

This will, for the next three years, entail the compilation of detailed insect records on as many varietal types of cotton as possible, in conjunction with plant development records. It will be carried out on the main station situated in one of the principal alluvial belts and will be supplemented by similar records on six large plots covering the drier and intermediate areas and also the alluvial type of soil.

[1] W. V. Harris. "Insects Injurious to Cotton in Tanganyika Territory." Pamphlet No. 29, Dept. of Agriculture, 1942.

General Account of the Work During 1943.

The following Report for 1943 covers this work on the main site at Ilonga, near Kilosa, and that on the six district plots scattered over the various types of country mentioned, in the Morogoro district.

As the area planted to cotton on the main site was little more than a large district plot, all results have been considered together, only major points of difference being mentioned.

Only essential details and the general trend of events have been included as the work is still in the preliminary stages.

Meteorology.

Rainfall for the season was very unevenly distributed. The December–January rains were a partial failure. Conditions during the latter part of February were good and the non-native estate cotton planted at this time came away well. Dry conditions followed during the first half of March but rains during the latter part of the month, in April and early May, were good. For the Stations Ilonga, Mgera, Morogoro and Mvomero, the total rainfall for this, the most important part of the season for cotton-growing, was between 15 and 20 inches. At Kingolwira Farm the total for the same period was in the neighbourhood of 8 inches.

Agriculture.

As a result of the rainfall distribution described, planting of all crops was generally late. This was particularly so in the case of native cotton which was probably two or three weeks later than is usual for most of the area. The non-native crop was planted about mid-February, approximately the normal time. The cotton at Ilonga and in the district plots was planted over the period from March 18th to April 8th, corresponding roughly with native planting.

Cultivation Trial.—A cultivation trial was laid down in five of the plots. This included comparisons between dug and undug plots, ridge and flat cultivation, combined with spacings ranging from 6 feet × 3 feet to 2 feet × 2 feet. Results showed that the wider spacings were definitely poorer in yield, the safest probably being 3 feet × 3 feet. No differences were observed between dug and undug plots, while yields from the ridged plots were generally lower.

Cotton Breeding Work.

This at present is mainly confined to the testing of different varieties and strains of cotton with particular reference to plant development in conjunction with the incidence of insect pests.

A variety trial was established in each of the plots containing the following types :—Mz.561, the present commercial seed of the Lake Province ; Malwa Upland MU8A, an extremely hairy type ;

Mz.457; K35/553, a Kingolwira selection from Eastern Province Local; 6250, a quick-maturing Barberton U.4 derivative; and Eastern Province Local. As there was only a limited amount of seed of MU8A, a quick-maturing hairy derivative of U.4 from Gatooma, 9L.18, was substituted in some of the plots. The plots may be classified according to conditions as (i) Alluvial soils.—Ilonga, Mvomero, Kwa Dihombo. (ii) Intermediate.—Morogoro, Mgera, Kingolwira Village. (iii) Dry.—Kingolwira Farm. The yields are given in the following table :—

TABLE OF YIELDS IN VARIETY TRIAL FROM DISTRICT PLOTS, 1943.
(*Yields in lb. seed cotton per acre.*)

Place.	*MU8A.*	*9L.18.*	*U.4 6250.*	*Local.*	*K553.*	*Mx.561.*	*Mz.457.*
Ilonga	1,290	—	1,039	951	1,073	1,064	1,032
% Stand	83%	—	85%	99%	95%	96%	99%
Kwa Dihombo	816	—	720	675	910	713	858
% Stand	77%	—	71%	88%	94%	87%	92%
Mvomero	941	—	848	695	758	723	737
% Stand	74%	—	56%	80%	78%	67%	77%
Morogoro	—	848	751	771	1,024	948	889
% Stand	—	60%	60%	91%	89%	92%	83%
Mgera	—	713	893	692	865	969	996
% Stand	—	73%	77%	85%	93%	90%	93%
Kingolwira Village	—	398	415	308	547	543	460
% Stand	—	84%	70%	96%	96%	91%	96%
Mean	1,015	653	777	715	863	827	829
Mean % Plant Stand ...	78%	72%	70%	90%	91%	87%	90%
Kingolwira Farm	—	176	62	138	176	149	173
% Stand	—	38%	29%	64%	52%	52%	60%

The main point which emerges from the results is that all types gave considerably better yields than Local. While, with the exception of MU8A at Ilonga, the yields are not significantly different from Local, the results are from a wide range of conditions, so that some weight can be attached to them. Particularly is this so when the yields are considered in conjunction with the plant stands. The principal reason for the increased yields over Local lies in the higher flowering rates of all types and especially that of MU8A. The U.4 types and MU8A were included in the trials solely on account of their early maturity and high flowering rates. They cannot be considered as possible substitutes for the present seed on account of their poorer lint quality. One other satisfactory point which appears is the consistently better performance of the Kingolwira selection 553 over Local. Preliminary reports from ginners indicate that the lint of 553 does not differ in quality from that of Local. Samples are being sent to the Shirley Institute for further examination.

Selections.—The Kingolwira collection of single plants has been transferred to Ilonga, together with a number of special bulks. It has not been possible to devote much time to these in the present season owing to the survey work on Ilonga itself. Sixty-four selections and re-selections have been carried forward for planting in 1944. No detailed analysis of lint quality was possible owing to lack of facilities and trained staff.

Insect Pests.

Continuous records of the main insect pests were taken throughout the season over all plots and in three commercial crops. Of these last two were interplanted in maize. The native recorders have now become more acquainted with the work, but records are still of the simplest possible type.

Jassid (Empoasca spp.).—There were indications of this pest everywhere but only when the plants were under unfavourable circumstances was serious damage seen.

American Bollworm (Chloridea obsoleta).—Continuous records in the form of larvæ counts were made in and around Kilosa on a succession of maize crops. These, together with the general observations and spot records taken in the vicinity of the district plots, showed a similar course of events in bollworm incidence on maize.

The situation varies in degree over the area, particularly as in Kilosa district there are very large areas of non-native maize. The evidence so far obtained shows only one generation in each crop. Bollworm larvæ were recorded in the earliest-planted maize during February and March. The main larval population developed during April and May when the bulk of the maize crop, which was planted in January and February, came into tassel. The last record of larvæ in the latest-planted maize was the middle of June. Observations on the pupal period of larvæ taken from the main maize crop indicated a maximum moth emergence during May and early June, which period may be extended by about ten days to cover the oviposition life of the moth.

Larval counts were carried out on all the experimental cotton plots and, in addition, on two February-planted commercial crops in Kilosa district. These early crops, which started flowering in mid-April, showed a larval population at that time indicating that egg-laying must have taken place by moths bred in the very early maize. Larvæ continued to be recorded in these crops until the end of June. The later experimental cotton did not flower until towards the end of May, and showed a larval population at this point which also continued to the end of June. Thus the later-planted crops were subjected to an attack by this pest of much shorter duration, corresponding almost completely with the difference in planting dates. The intensity of the attack on the experimental cotton was very similar throughout, with the exception of one plot where the early crop was very severely damaged. The plants recovered after the disappearance of the larvæ and quite a reasonable crop was picked.

There is thus a suggestion that later planting, particularly with a more efficient plant type, might lead to a decrease in loss occasioned by American bollworm, a point which requires further investigation.

With regard to other food plants, detailed searches in sorghum crops failed to show the presence of larvæ. Pigeon peas (*Cajanus*

indicus) gave larval populations from mid-June onwards into July. As the crop is in flower at the same time as cotton it may be that a certain amount of egg-laying was diverted to it.

Pink Bollworm (Platyedra gossypiella).—Larval counts first showed the appearance of this pest in very small numbers in May. It was not again recorded until towards the end of July. From this point populations rose rapidly and reached very high figures in August and September, between three and four thousand per acre being recorded in a commercial crop near Kilosa. It is significant that on new land, both in experimental cotton and in a commercial crop, the pest was a full month or more later in appearing than in older land where cotton had been grown the previous year, emphasising the need for complete and early uprooting and burning of the crop.

Spiny Bollworm (Earias spp.).—This pest was observed in all cotton from the commencement of flowering until late in the season. While populations were not high enough to warrant its being rated as of major importance in itself, it is yet another cause of loss and damage to the plant, particularly on account of its prolonged presence in the crop. A point of interest in connection with it is that in crops seriously damaged by American bollworm and Capsids early in the season, which produced much leaf and new growth later, populations remained at a much higher level throughout.

Stainers.—Four main species were recorded :—*D. fasciatus*, *D. intermedius*, *D. cardinalis* and *D. nigrofasciatus*. One specimen of *D. superstitiosus* and one of *D. migrotorius* were taken. The distribution and importance of the individual species varied somewhat from place to place, generally, but not always, with the planting date.

In the February-planted commercial cotton, that near Kilosa showed *D. intermedius* to be the main species early in the season, and it remained in the crop throughout. There was a small early influx of *D. fasciatus*, but the species practically disappeared during June and July. It reappeared towards the end of July and reached very high figures in August and September. *D. cardinalis* and *D. nigrofasciatus* appeared in relatively small numbers through the season.

In two of the early crops, distant about twenty-five and fifty miles north of Kilosa respectively, the distribution was different. *D. cardinalis* more or less completely replaced *D. intermedius* in the early part of the season during May and June, with *D. fasciatus* as of secondary importance. Very few stainers were recorded in this February cotton after June.

The later-planted March/April cotton generally showed *D. intermedius* to be the most important species in the early crop, with *D. fasciatus* the main species from August onwards. *D. cardinalis* and *D. nigrofasciatus* were of secondary importance.

No breeding took place in any of the species until after the first bolls had opened. In practically all plots there was a fall in the total

population of adults of all species in June and July, varying somewhat with time of planting.

In view of the suggestion from native evidence that early-planted cotton usually had more of the early crop destroyed or damaged, a census of open bolls was undertaken for all plots and in three commerical crops. The census was based on the weekly examination of the seed-cotton of all open bolls from random samples. These were classified locule by locule into five groups: (i) Completely destroyed by bollworm. (ii) Grade III attributable to bollworm. (iii) Completely destroyed by stainer. (iv) Grade III attributable to stainer. (v) Grade I.

The final results of this census show that, in so far as stainer and bollworm damage can be assessed, the first crop of the February-planted cotton, which opened in June and July, was very severely damaged. That opening in August and September was less severely damaged, while the October crop was either completely destroyed or all Grade III.

Comparison of two early commercial crops planted in February with their adjacent district plots planted in March and early April respectively, show the following final results, which, though not strictly comparable on an experimental basis, indicate higher percentages of Grade I seed-cotton in the late plantings.

Place.	*Date Planted.*	*Grade I. %*	*Yields per acre in lb. seed cotton.*
Kilosa	20/2/43	41·5	468
	23/3/43	56·7*	951
Mvomero	22/2/43	63·1	710
	8/4/43	74·4	695

* This percentage would have been higher had it not been for an enormous influx of stainer into the plot immediately after the second picking on an adjoining estate. The population increased from roughly 2,200 per acre to 15,000 in the period from the 5th to the 12th August, and became even higher later.

The plots on Kingolwira Farm and at Kingolwira Village do not conform to this trend. They reflect the much more difficult insect pest situation, in that serious damage was inflicted on the crop through the season. Their final figures for Grade I were 49% and 43% respectively.

Thus, on this season's distribution of stainer and bollworm, later planting would appear to have been more satisfactory. The extremely severe damage to the October pickings demonstrated, in this season, the futility of delaying uprooting and burning in the hopes of obtaining a late crop.

Calidea.—Was observed only in negligible numbers throughout the season. *Oncopeltus* and *Serinetha*, identified by Mr. Harris, the Entomologist, were taken on cotton at Ilonga.

Helopeltis.—Records of this pest are not easy as it is very active in the field. Only at Ilonga was it taken in any numbers, a peak

figure of 220 per acre being reached in July. The significance of this figure is not understood at present owing to lack of experience of the pest. Surface damage to bolls and damage to vegetative parts of the plant were common, but few really serious cases were seen. The importance of this pest from year to year remains to be investigated.

Capsids.—The appearance of this pest varied very much over the range of crops examined. Judging by the leaf damage it was present everywhere, but only on two plots could it be said to have been really serious. In one, near Kingolwira, very serious damage, which must have led to suppression of flowering, occurred early in the season. In two plots on the alluvial soils the pest caused damage much later in the season.

The whole question of Capsids has been discussed with Mr. Harris. The matter is very complicated as there are several species which may be involved. Detailed studies of the subject are required, but under present circumstances, owing to the difficulty in obtaining material necessary for the requisite type of insectory, it is difficult to see what can be done other than the taking of rough observations in the field.

Mycology.

Blackarm Disease (Bacterium malvacearum).—A certain amount of damage caused by this disease was seen everywhere ; it was particularly in evidence on a plot near Morogoro, but could not be said to have been serious.

Station.

The piece of land cleared at Ilonga near Kilosa was not found to be satisfactory owing to water troubles. Permission was obtained from the owner to survey the whole area.

The land lies at the base of the escarpment hills and is covered with thick forest and bush. It has probably not been cultivated for forty years or more. Traverses were cut through the bush and the area mapped by compass, a total of about 1,500 acres being covered. Soil pits were also dug at intervals. As a result an area of some 900 acres has been found which would be well suited for a station site ; it is capable of expansion to include poorer worked-out soils. Care will have to be exercised in clearing as, although the slope of the land is reasonable, the proximity of the escarpment hills may lead to erosion troubles. There is permanent water nearby and a suitable housing site has been reconnoitred.

For the present, permission has been obtained to clear sixty acres of land in the centre of the proposed site for use over the coming three years.

A small ginnery has also been established with one roller gin and one forty-saw gin in a nearby disused railway station.

Summary.

(i) The season, although later than usual owing to a drought period in March, was generally satisfactory.

(ii) A variety trial indicated that types with higher flowering rates gave better yields than Eastern Province, Local.

(iii) There was a suggestion that under the season's distribution of American bollworm and stainers, later planting with a more efficient type of plant might be a partial solution to the problem of increasing yields.

(iv) A new area of land has been surveyed at Kilosa and clearing of a preliminary sixty acres has been started.

PROGRAMME OF EXPERIMENTAL WORK 1944.

Recording of insect pests in conjunction with plant development of different varieties and types will be continued. These records will be made on six district plots in addition to the main site.

Various strains of Eastern Province Local will be tested in trials on all plots.

In so far as is practicable selection work will be continued.

NOTES ON THE SEASON 1944.

This year the planting of grain and pulse crops rather than cotton was emphasised as being the agricultural policy necessary to the war effort ; this led to an increase of the acreage planted to food crops by both natives and non-natives at the expense of the cotton acreage.

The season was a difficult one. The short rains did not break until the beginning of January, and after a short rainy spell of about fourteen days there followed a drought lasting until the middle of March.

As a result of this drought, coupled with widespread outbreaks of Army worm, very severe damage was caused to crops planted in January. Much replanting of food crops was therefore necessary when the long rains commenced in March. This caused a further reduction in the cotton acreage and led to very late planting. Growth in many cases was retarded by exceedingly heavy rains during April and the early part of May. Thirty inches fell in 65 days at Ilonga.

During June and July severe attacks by American bollworm took place throughout the Province and serious loss of crop was caused. In view of this combination of circumstances it is hardly surprising that the crop for the Province is the lowest on record for many years.

Experimental Work.—The insect and plant development records were continued at Ilonga and on the six district plots on the same lines as during 1943. All yields were very much lower than in the previous year, principally due to the American bollworm attack. Populations of adult stainers were in most cases larger in the early crop, the most important again being *D. intermedius*.

The results show again, however, that the early and prolific types under test have given better yields than Eastern Province Local. In this respect MU8A is again outstanding. It is unfortunate that Uganda BP.52, the only type in the variety trials definitely better than Local for lint quality and ginning percentage, gave somewhat disappointing yields. In addition to the variety trials, strain and spacing experiments were carried out on all plots, but details of these are not yet available. A certain amount of selection work was carried out on Ilonga, where a total of 45 acres was eventually planted to cotton.

NOTE ON COTTON-GROWING IN THE NORTHERN AND TANGA PROVINCES

BY

A. G. BEBBINGTON AND A. H. McKINSTRY.

This area was surveyed during 1942 and its problems would seem to be fundamentally similar to those of the Eastern Province.

Production over the period 1936–1942 has varied from 3,000–6,000 bales a year. This is obtained from roughly two types of country :— (i) The Northern portion where cotton-growing is restricted to a narrow belt of land lying immediately beneath the various mountain masses. The soils are not alluvial, but good supplies of surface water are available and irrigation is possible in most places. (ii) The Southern portion which resembles very closely the drier parts of the Eastern Province.

On the basis of our short survey it is only possible to give one or two of the points of difference between these areas and the Eastern Province.

Throughout the whole area maize is the staple food crop as distinct from the mixtures of grain crops in the Eastern Province, where maize is mainly an important subsidiary. This probably has an important bearing on the American bollworm situation.

The main mass of the population in the Northern area live in the mountains themselves where European crops such as potatoes, vegetable and coffee are grown. Cotton is grown either by immigrants who have settled beneath the mountains or by the mountain people who come down to the plains particularly for that purpose, and to grow sugar cane. Thus, in this respect, the mountain-grown crops are formidable rivals to cotton. As the growers only stay below for short periods the crop suffers from lack of cultivation.

The irrigation possible in the Northern portion prolongs the growing season, as do the moisture conditions of the alluvials of the Eastern Province, allowing of recovery from early insect attack to some extent.

The insect pest situation would appear to be very similar to that in the Eastern Province except with regard to American bollworm, which, as stated, is probably influenced by the fact that maize is the staple food crop. In the Southern portion many crops had been completely stripped of bolls by this pest. Any attempt at recovery, difficult owing to the dry conditions, was being prevented by Capsids.

In the North similar damage had been inflicted, but a certain amount of recovery was taking place owing to the irrigation of the crop.

Much enquiry among the native growers gave the following information :—(i) They did not in any year expect to pick the first crop set. (ii) Although normal planting is in March their first picking was normally taken in October–November, seven to eight months after planting.

It would seem that bollworm might always be responsible for this, particularly in view of the large maize crops, which with ample irrigation it would appear to be possible to plant almost at any time.

NYASALAND

COTTON EXPERIMENT STATIONS

Introductory Note

BY

H. C. DUCKER.

The general agricultural circumstances and policy of the country have remained unchanged in 1943/44, and there is little to add to previous statements.

Government has under consideration post-war development schemes for all three of the main cotton-producing areas in which irrigation, in North Nyasa and the Lower River, may play a part. Such schemes will do much to alter the cotton picture if they are put into practice.

The marketing scheme, common to all British East African territories, whereby purchase of cotton is guaranteed for the duration of the war and for one year thereafter, has continued to work well; but since in effect it has stabilised cotton prices to the African, whereas those of tobacco have remained uncontrolled and have boomed, it has not enhanced the popularity of cotton in the Central summer crop areas, which can grow both crops.

These summer crop areas suffer further from the disadvantage that in them cotton, at its most critical early seedling stage, competes directly with the food crops for the African's time and attention, and will continue to do so till he is prepared to systematise his agricultural practices and devote more of his time and energy to his crops than he does now. The difficult planting season of 1942/43, and the even more difficult season of 1943/44, have emphasised this disadvantage, and there has been a big drop in cotton production in the Central Areas.

No experimental work has been done in North Nyasa, this past year, where the winter crop cotton continues to give very satisfactory results from both the native growers' and European buyers' points of view. The North Nyasa lint is selling at a premium at present and it is a matter for regret that the area producing this crop is not larger.

Work at Domira Bay has continued to attack the problems of summer crop cotton, and the Insect Pest Control Section have continued with their critical work on Red bollworm (*Diparopsis castanea* Hmps.) in the Lower River. This work on our major cotton pest is now almost completed and the summary of a report on it to Government is included in Part II of the I.P.C. Section progress report.

Much better returns of commercial cotton are being obtained from the Lower River areas this year than last, and once again we are seeing a swing of the crop loss pendulum. The bulk of the Lower River crop was planted in January and February.

There have been no staff changes during the year, except that Mr. B. L. Mitchell moved from Limbe to Zomba to relieve Mr. E. O. Pearson when the latter proceeded on leave. He remained there to assist Mr. Pearson with the writing of the full Insect Pest Control Report, when the latter returned from South Africa.

Once again a cyclonic storm has affected Domira Bay, but on a small scale this time, and damage was slight, being confined to the roof of one of our seed stores. Repairs are being done by the Station labour at the time of writing.

DOMIRA BAY STATION

PROGRESS REPORT, 1943-44

Part I.

BY

H. C. DUCKER AND W. L. MILLER.

General Survey of the Season and of the Experimental Work; and Conclusions.

Meteorology.

The total rainfall for the season was 26·99 inches, the lowest so far recorded since the Station began work. It was a complete contrast to that of last year, both in amount and distribution. November and December rains were almost a complete failure, though two showers on December 29th and 30th were sufficient to germinate cotton. The first good rains commenced on January 8th, and the last effective rain fell on March 20th.

Cotton behaved quite well under these difficult conditions, but food crops suffered severely. Native agriculture was badly upset and the Africans' preoccupation with their food crops caused them to neglect their cotton very badly.

Agriculture.

Cotton.—Mz.561 was used as the main station bulk and did well in spite of the season. Yields were satisfactory in spite of the use of new land, cleared to enable the main rotation to be organised as previously reported. The mean yield for the whole acreage of 430 lb. seed cotton per acre does not reflect the performance of this variety truly; up to 764 lb. seed cotton per acre was obtained on some of the older fields.

The large-scale commercial trial of Mz.561 on the Golomoti estate of the African Export Corporation Ltd. gave results which were

highly gratifying to the native tenant growers and to the manager. All available seed from this estate and from the Station has been handed over to Government for further commercial trial and multiplication. The mean ginning out-turn was 31·49%, which is better than had been expected, and spinning tests to date suggest that in Mz.561 we have an improvement in quality on Crown Land commercial U.4.

A small bulk trial, which will be referred to later under " Genetics and Breeding," contained Mz.561 mass-selected bulk and C.L. commercial U.4. Taking the yield of the latter as 100 in terms of seed cotton, Mz.561 gave 116 on the first picking and 109 on the total pickings. The first difference is significant at P=0·05.

To follow the sequence of crop formation and loss, all flowers were tagged in a random series of plots marked out in one field of Mz.561 bulk. The results are of interest and their summary follows :—

Analysis of Tagging Totals.

Total flower production	3,492	100%
Total sheddings due to bollworms	368	10%
Total sheddings due to non-bollworm causes	2,095	60%
Total ripe bolls production	932	27%
Tags lost by accident	97	3%
Totals	3,492	100%

Analysis of Ripe Bolls.

		Equivalent Boll Counts.	
Total number of locks	3,824	932	100%
Total number of clean locks	3,117	760	81·5%
Total number locks damaged by bollworm	31	8	0·8%
Total number of locks damaged by non-bollworm causes	676	164	17·7%
Totals	3,824	932	100%

As far as can be ascertained, the main non-bollworm loss was due to " natural " shedding, probably resulting from the drought conditions which obtained in April and May. But it may well be that there are other factors which could bear examination, and an attempt will be made to trace them.

There is nothing to add to last year's note on Red bollworm control, which at Domira Bay has now remained at much the same level of efficiency for seven years.

The rest cropping experiments have continued on the lines planned and described in previous reports. It will be several years before more results can be expected.

A cotton inter-cultivation experiment, done in one five-acre field of Mz.561, yielded striking results, and demonstrated very clearly the extreme importance of early weeding. This experiment confirms earlier work in 1937/38, and is dealt with in more detail in Part II of this report.

Rotation Crops.

General.—No significant differences were obtained in the maize pre-cultivation experiments which have been continued. Advantage was taken of the " dug " and " not dug " cotton plots used by the I.P.C. Section for pupal mortality studies to augment the new experiment mentioned last year. There was no significant difference in yield between " dug " and " not dug," using maize as the testing crop. By digging is meant the normal hand hoe work of 2½ inches to 3 inches depth.

The groundnut rotation experiment has reached its penultimate year and will be tested with groundnuts sown in all plots next season.

Maize.—This has been the most difficult year for cereal crops we have ever experienced and even sorghum suffered severely ; maize fared worse and had to be planted twice in all fields, three times in some, and four times in one field.

The older land did better than some of the new fields, but yields generally were very low on Domira Bay standards. They averaged barely 6 bags (of 200 lb. net wt.) per acre.

The shortage of early rains checked the weeds as well as the crops and when a good rain did come about the second week in January, everything started growing at the same time. Weeding was then very difficult, since our labour force could not deal with all the fields at once.

A new yellow selection from native stock did very well in a " garden " plot, and will be tested next year against the Station bulk. We are still looking for maize with a high carotene content.

Maize yields in the exhaustion plots of the five years soil restoration experiment were very low indeed.

Groundnuts.—This crop did better than maize, but yields were only about two-thirds of normal. No experiments were done in the groundnut break of the main rotation, but the collection of varieties has been maintained in one-acre bulks.

Pigeon Peas.—There is nothing to add to last year's notes, except to mention the provision of a comparison between pigeon peas plus elephant grass and pure elephant grass in the three-year rest plots of the soil restoration experiments.

Elephant Grass.—This has done well in spite of the dry conditions, and the fact that it does not occur naturally in the Station lands. The first experimental area of this crop, time of planting and spacing plots laid down for three years, has been cleared without difficulty this season and will be tested with cotton in 1944/45.

The use of old fields of elephant grass due for clearing, for stocks to plant new areas, is to be recommended. It helps to weaken the stand prior to clearing.

Miscellaneous Crops.—Cluster beans again did well and the Director of Agriculture has asked us to multiply our stock for general trial ; we have now 54 lb. seed, derived from two viable seeds supplied to us in 1942.

No other crop is worth mention except the citrus orchards which continue to do well. The new orchard to supply a citrus ration to our labour should be in full bearing in two to three years' time. It was not allowed to carry fruit this season in order to avoid weakening the young trees.

Tanks and Dams.

The short rains hardly gave these a fair trial, but over six feet of water was trapped in Dam 1A. This mainly went to increase the subterranean supplies and the dams were both dry again by July.

The work of raising Dam 1A was completed, and a third dam site has been surveyed. It is intended that the three dams, when complete, shall form an inter-connected series, the highest draining to the second highest and thence to the lowest of the series.

The scheme has recently been inspected and reported on by the Government Geologist, who considers that it should yield some valuable experimental evidence and has provided details of records he would like to be kept on the behaviour of the dams and their effect on ground water supplies.

Cotton Genetics and Breeding.

The derivatives of Mz.561 were planted in multiplication plots and in a small bulk trial for comparison with the parent bulk, Crown Land commercial U.4, our two U.4 × Cambodia × U.4 crosses (N.C.4 and N.C.7), and the first C.L.U.4 selection to breed true—C.L.119. In addition, a special " black seed " bulk of Mz.561 was included. This was derived from the parent bulk by hand picking naked and naked-tufted seeds.

The final pickings showed that nine of the derivatives were significantly better yielding than C.L.U.4, and of these four have been selected for further multiplication and trial. One of these, T.3, had far better jassid-resistance than its fellows. Spinning tests, kindly carried out by the B.C.I.R.A., indicated that in the Mz.561 derivatives we have a better type of lint than that produced by C.L.U.4. Coupled with good yields, this suggests that in Mz.561, Nyasaland version, we may have achieved a real advance.

Yields were good for the site and season, ranging from 730 lb. per acre for the best Mz.561 derivative, T.3, to 567 lb. per acre seed cotton for C.L.U.4.

There was no significant difference in yield between Mz.561 " fuzzy seed " and Mz.561 " black seed," but the former ginned 1·2% better and had a lint index of 4·0 compared with 3·8 for the " black seed." The two lots of lint will be compared in spinning tests.

T.20, the second best yielder of the Mz.561 derivatives, proved heterozygous for fuzz type and contained 6% "black seed." It was also lower in ginning outturn and lint index than its fellows. C.L.119 proved significantly lower than C.L.U.4 in yield and will be dropped, since C.L.20, put back to the progeny row stage last year, has given most promising results.

The C.L.20 family now consists of twenty-two sub-strains, all of which will be tested in small bulk trials next season. The two mass-selected Ukerewe bulks yielded no useful selections and have been discarded.

A range of U.4×Cambodia×U.4 crosses made at Barberton and kindly supplied to the Station by Mr. Parnell, was grown in observation plots. None proved particularly outstanding, but all merit and will receive, further trial.

A.2208, a Malwa Upland×U.4 cross made at Barberton, also supplied by Mr. Parnell, was much more promising, and it has set new standards for jassid-resistance at Domira Bay. Local selections have been made from this new cross, and selfed, and natural bulks are being carried forward for further trial. Mr. Parnell is kindly supplying other Malwa Upland crosses for trial this coming season, as well as some "quality" crosses of other parentage.

The *religiosum* (*punctatum*) cottons supplied by Mr. Hutchinson from Trinidad, have again been grown in observation plots, both at Domira Bay and at Chiromo—at the latter place to see if they would retain their late-flowering habit under Lower River conditions. They did so, but Mr. Pearson reports that they are hardly late enough to be effective in controlling red bollworm.

It is now thought that the work of selecting and breeding "late-flowering" types had best be referred to the geneticists at the new Central Research Station, if "delay action" cottons are really needed.

Summary of Main Conclusions.

1. Mz.561, Nyasaland version, is proving very satisfactory and is probably an improvement on Crown Land commercial U.4. It is worthy of and will receive extended commercial trial.
2. Red bollworm control was satisfactorily maintained at Domira Bay, but non-bollworm loss may merit closer examination.
3. The benefits of early weeding of summer crop cotton were again clearly demonstrated.
4. Pre-cultivations, their necessity or otherwise, deserve and are receiving close attention.
5. The experience of a real droughty year has demonstrated once more that cotton can withstand harder conditions than can the common food crops of Domira Bay.

6. It seems possible that in the derivatives retained for planting in 1944/45, the high-yielding constituents of Mz.561 bulk have been isolated, and that there has been no loss of quality in doing so.

7. A simple investigation of " black " or fuzzless seed tends to confirm Uganda work on this group of characters.

8. The C.L.20 family selected from C.L.U.4 is most promising. Its original heterozygosity has made it a good subject for re-selection.

9. Malwa Upland, crossed with a U.4 strain, has set new high standards for jassid-resistance at Domira Bay. Intensified work on this and allied families seems well worth while.

10. There is an element of doubt regarding the utility of late-flowering types in defeating red bollworm. It is thought that work on the genetical aspects of such types will best be referred to the new Central Research Station.

PROGRAMME OF EXPERIMENTS, 1944-45 SEASON.

Strain Trials.—Trials will be carried out to compare Mz.561, C.L.20, U.4 × Cambodia × U.4, Malwa Upland × U.4 and other families, and will be augmented by district trials which the Department of Agriculture has promised to undertake for us. These district trials will compare the cottons now ready for commercial trial with existing C.L.U.4 stocks.

Increase Plots.—The most promising of the above-mentioned stocks will be multiplied in selfed and natural plots.

Breeding Plots.—The most important range of material to be added to these will be that of " quality " crosses and parent stocks of good lint type from Barberton. Some new material is also coming from Uganda.

Rotation Crops and Experiments.—All current experiments will be continued and some new pre-cultivation experiments attempted with cotton, groundnuts and maize. A special " deep cultivation " experiment with cotton, to establish whether this will have any effect on drought-resistance, has been laid out.

The Insect Pest Control staff will be leaving Nyasaland this year and the formal entomological work will close down ; the question of continuing routine pest records is being discussed before Mr. Pearson goes.

DOMIRA BAY EXPERIMENT STATION.
PROGRESS REPORT, 1943-44.

Part II.

There is only one piece of work done at Domira Bay this past year which will not be repeated and can properly qualify for this section. It has, however, the merit of clear-cut simplicity and completeness in its answer to a major native problem with summer crop cotton, the question of early inter-cultivation of the cotton crop to prevent weed competition.

The experiment was based on a five-acre field of Mz.561 bulk cotton and consisted of the following variables, in a randomised block layout using eight replications.

Main treatments.

A. Plots hand-hoed and *cleaned before thinning.*

B. Plots hand-hoed and *cleaned after thinning.*

Sub-treatments.

1. Plots given *one subsequent cleaning.*

2. Plots given *two subsequent cleanings.*

Variables were A1 and A2, B1 and B2, four in all, making a total of thirty-two plots. Plots were 110 yards long by 5 yards wide.

A2 plots approximate to normal Station practice in cotton cultivation, B1 plots to the general run of native gardens. A1 represents about the best we can expect of the native in his present state of agricultural education.

The treatment effects were assessed by the seed cotton yields and the results are given below in percentage form, using the A2 plots as standard=100.

Variables.	*Yields as Seed Cotton.*	*Differences.*
A2	100 } Mean 91·5	Sig. Diff. = 10 (P = 0·05)
A1	83 }	A2 — A1 17
B2	40 } Mean 33	Mean A — Mean B 58·5
B1	26 }	B2 — B1 14

The enormous importance of early cleaning is manifest, and this is exactly where the African of the Nyasaland Central Areas so often proves wanting.

When his cotton plots are in greatest need of cleaning he is apt, in his present stage of unsystematic agriculture, to neglect it in favour of food crops. One cannot blame him for thinking of his food crops first, but since the rotation cropping work at Domira Bay has indicated already that a modicum of planning will greatly facilitate the early hoeing work, it is to be hoped that matters will improve in time, and cotton suffer less from neglect.

The above experiment probably has some bearing on the failure of inter-planted summer crop cotton at the station, and in those native gardens this past year whose owners attempted to follow the Lower River semi-summer crop practice of inter-sowing cotton in maize. With the short season of the Central areas both crops must grow and mature over the same period, and the strong-growing maize merely plays the part of weed growth in strangling the cotton.

ENTOMOLOGICAL WORK
PROGRESS REPORT, 1943-44

Part I.

BY

E. O. PEARSON and B. L. MITCHELL.

Introductory Statement.

Work in this section has continued to be directed towards the solution of the problem of insect pests, principally the red bollworm (*Diparopsis castanea* Hmps.), in the Lower River cotton crop.

By the end of 1943 season the laboratory and field experiments had gone some way to explain the central problem of the bionomics of red bollworm, viz., the mechanism of the carry-over of the pest from one season to the next by long-term pupæ. This information, together with deductions from the routine field recording, had suggested that the best method of control of this pest, under present conditions on the Lower River, would be an early-maturing crop, uprooted very much earlier than is at present the case, with the object of concentrating boll production, so far as possible, into that time of year when a minimum of long-term pupæ are formed.

It was realised that this would entail first of all some modification of the present system of interplanting cotton in food crops and, second, some method of dealing with such long-term pupæ as would still unavoidably be formed. The programme for 1944 was therefore planned, (*a*) to give confirmation of the theory of the carry-over mechanism and to elaborate it, with special reference to the factors inducing the formation of long-term pupæ ; (*b*) to explore possible methods of overcoming the difficulties inherent in early production in cotton interplanted with food crops ; and (*c*) to test ancillary methods of minimising the survival to the next crop of such long-term pupæ as would still be formed.

The possibility of starting the new régime with a clean sheet by preceding it with a non-cotton season has also been considered : to this end experiments had been planned on the distance which could be covered by mass movement of bollworm moths, and information was also sought on the exact status of cotton-growing in Portuguese

territory adjacent to the Nyasaland Lower River areas. Information on mass migration was especially needed in connection with the possibility of spreading the non-cotton year over a number of successive years and zones, but tentative enquiry showed that this approach was less likely to be acceptable than the bolder one of putting the whole area out of cultivation for a full year. The need for this information was thus less pressing and, with an already overloaded programme, the experiments, which would have been very difficult to carry out, were dropped. An extremely useful reconnaissance of adjacent territory in Portuguese East Africa was carried out, the results of which need not be reported here. They show that the danger of insect interference with any proposed control measures from across our borders are, happily, slighter than had been thought.

Main Conclusions Drawn from the Results of this Work.

Routine Recording.

The carry-over of long-term pupæ from 1943, though not as great as in the previous season, was high enough to take the whole of the fruiting points as they formed and it was not until the end of May that any real flush of flowering occurred. Emergence of the carry-over generation was late and thus offset the fact that planting was also late. Nevertheless, having set no early crop the plants did not lapse into senescence, and good cool season rains enabled a big flush of flowers to set in May–July, partially swamping the bollworm population and producing a crop, harvested between late July and late September. This crop was considerably better than that of 1943, but, at an estimated yield of 178 lb. seed cotton per acre, was still most unsatisfactory by any reasonable standard of cotton-growing.

Stainer did not come into the crop in numbers until the cool season had well started and breeding was restricted, as is usual under these circumstances. Only in early plantings which had set more pre-cool season crop was immigration early and substantial enough to allow large populations to be bred *in situ*. The commercial crop was, in consequence, fairly clean (84.5% No. 1 grade).

Laboratory Experimental Work.

In last year's report the nature of the long-term pupal period and the effect of various factors upon it were described, and it was shown how the phenomena described explained the actual course of events observed in the field. Much of this deduction was based on experiments with pupal material collected in early September, 1942. Since writing last year's report a great deal more detailed work, using 1943 collected material, has been completed. The results of this work confirm the conclusions previously reached, in general. Certain modifications or elaborations are given below. In the section which immediately follows, however, we have had disappointing results.

(i) *The formation of Long-Term Pupæ.*—Larvæ, derived from eggs laid by moths emerged from long-term pupæ of the 1943 season and incubated at 30°C., were reared in the laboratory over a wide range

of constant and fluctuating temperatures. They were allowed to pupate and the pupæ were subsequently incubated at 30°C. All of these gave rise to short-term pupæ.

Small numbers of larvæ reared at 30°C., derived from the moths of the first generation bred in the field in the 1944 season, also gave wholly short-term pupæ.

Eggs laid by moths from long-term pupæ, incubated over a wide range of alternating temperatures, the larvæ and pupæ from which in turn were incubated at 30°C., also gave short-term pupæ.

The months in which long-term pupæ are formed in the field are characterised by boll temperatures in which the daily range exceeds and the minimum temperature is below, 20°C. Particular interest, therefore, attaches to the behaviour of pupæ from larvæ bred artificially under such conditions. We succeeded in rearing less than a dozen such pupæ, all the offspring of moths derived from long-term pupæ, and all of them were short-term. We were unable, however, on account of the difficulty of obtaining adequate food supplies at the appropriate time, to test the effect of such temperature ranges on larvæ whose parents were themselves derived from short-term pupæ. Since the larval population in the field in the months in which long-term pupæ are being formed must be predominantly the offspring of moths from short-term pupæ, it is still possible that temperature is the controlling factor in inducing the formation of long-term pupæ, but that it requires to act on larvæ derived from a preceding generation of short-term pupæ.

The difficulties of synchronising food supply and egg supply—unavoidable where the necessary laboratory work cannot be carried out in the place where the crop is grown—and the very heavy mortality experienced even when food supplies are adequate,* has convinced us that in order to investigate satisfactorily the effect of temperature on the larval stages, mass breeding in artificial media, such as has been used in the case of the False Codling moth in South Africa, will be necessary. The results of the work on the effect of food, however, and such evidence as we now have on temperature effects, lead us to think that the case in favour of the proposed control method is sufficiently strong without embarking on further lengthy and complex research.

To sum up the results of the two years' experience of larval breeding at controlled temperatures :—

(i) There is definite evidence, no exceptions having occurred in nearly 200 pupæ, that the offspring of long-term pupæ, bred under conditions where the daily range is less than 20°C. and the minimum temperature is greater than 20°C., give rise solely to short-term pupæ.

* During the 1943–44 season only some 70 moths were successfully reared out of nearly 30,000 larvæ started off in the first instar.

(ii) There is evidence, based on small numbers only (16), that the offspring of short-term pupæ, similarly treated, also produce short-term pupæ. One exception occurred, with a pupal period of 60 days.

(iii) There is some evidence, based on very small numbers (about 13), that long-term pupæ are not produced from the offspring of moths from long-term pupæ by the action of alternating temperatures whose daily range is greater, and whose minimum temperature is less, than 20°C.

The position, therefore, is that whilst there is still no positive evidence in favour of low, or widely fluctuating, temperatures being the factor inducing formation of long-term pupæ, there is considerable evidence to show that where temperatures are moderately high and moderately constant, as is the case in the wet season months in the field, long-term pupæ are *not* formed, irrespective of the origin of the larvæ or the food on which they are reared.

Examination of the completed emergences of pupæ from the 1943 field feeding experiment confirm the statement in last year's report that the age of larval food does not determine the production of long-term pupæ. Significant differences in mean pupal period were obtained between batches of larvæ fed on different ages of food, but the proportion of long-term pupæ—some of which were formed on all types of food—was not correlated with food supply.

Although, therefore, the problem of what it is that induces long-term pupal formation is still unsolved, it seems reasonably safe to think that by shifting boll production, and hence larval production, back into the early months of the year, one will not increase the production of long-term pupæ and should, in fact, to a great extent eliminate it.

(ii) *Seasonal Variation in the Production of Long-term Pupæ.*—The proportion of long-term pupæ produced in the field has now been studied for two seasons by the method of collecting fully-grown larvæ in the field at weekly intervals, allowing them to pupate and incubating the pupæ at a constant temperature of 30°C. The results of the two years are given below, expressed as the percentage of short-term pupæ (arbitrarily defined as those emerging in 7 weeks or less). These figures are corrected, by periodical examinations, for mortality amongst pupæ and emerging moths, and thus differ slightly from, and supersede, those in last year's report.

Month of formation of pupæ	*March/April.*	*May.*	*June.*	*July.*	*August.*	*September.*	*October.*
% Short term pupæ—1943	99·0	95·1	80·1	74·4	57·0	57·5	58·5
1944	—	91·2		89·4	60·2	50·6	71·9

As observed in field pupation records, the population early in the season consists almost entirely of short-term pupæ, the proportion of long-term pupæ only assuming serious proportions in June, whilst August–September are the most dangerous months from the point of view of formation of carry-over pupæ.

(iii) *Seasonal Variation in the Pupal Period of Long-term Pupæ.*—The mean pupal period of long-term pupæ from different times of the year has been studied, using the material described in the preceding section.

Amongst pupæ formed in May, June, July and August in both 1943 and 1944, the distribution of emergences followed the same design as that described in last year's report for pupæ collected in early September, 1942, viz., a peak of short-term emergences at 3–4 weeks, and a peak of long-term emergences at about 18–20 weeks, the two peaks being separated by a very distinct trough of 6–8 weeks' duration in which practically no emergence took place. There was no significant difference in mean pupal periods of long-term pupæ from the different months, this being about 18–20 weeks. The frequency distribution curve is flat-topped and asymmetrical, with a high standard deviation and a long tail.

In populations formed in September and October, 1943 and 1944, however, there occur a considerable number of pupæ with periods of from 1 to 3 months, which very largely obscure the bimodal distribution observed in populations from earlier months, making it impossible to say where short-term emergences cease and long-term ones begin, and hence impossible to calculate a mean long- or short-term pupal period. It seems probable, however, that pupal periods are shorter than those in pupæ from earlier months.

(iv) *The Effect of Temperature on the Pupation Period of Long-term Pupæ.*—It was reported last year, as a result of comparisons of mean long-term pupal periods at 25°C. and 30°C. that "the long-term pupa is undergoing slow physiological change at a speed fundamentally pre-determined, but which may be accelerated or retarded by the temperature at which it is kept." This point was examined in more detail by incubating the long-term fractions of pupal populations collected in May, July and September, 1943, over the complete range of developmental temperatures.

The temperature-velocity curve for pupæ from all months showed a well-marked maximum at about 28·5°C., falling off quite rapidly both below *and above* this temperature. The temperature-velocity curves for May and July were very similar and the data from September, 1942 pupæ also fell into line with these. The curve for September, 1943 pupæ showed some difference, in that pupal periods at the same temperatures were significantly shorter than those from July pupæ.

(v) *Heat Inhibition of Long-term Pupal Development.*—Further investigations of high temperature inhibition of long-term pupal development were made, in which samples of a population believed to consist of long-term pupæ were exposed, when 4 weeks old, to high temperatures (36·7°C.) for periods progressively increased by fortnightly intervals from 3 to 21 weeks.

The experiments were devised to find the duration of the quiescent phase, this being the early part of pupal life, the duration of which,

as explained in last year's report, is thought to be unaffected by high temperature. On this hypothesis, exposure to high temperature should have no effect in lengthening pupal life until the period of exposure exceeds the length of the quiescent phase.

Unfortunately the material used was collected in September, 1943, and was characterised, as pointed out in (iii) above, by a high proportion of intermediates with pupal periods of 1–3 months. The interpretation of the results is extremely complex, since pupæ with differing " gross " pupal periods will differ also in the length of their quiescent phases. All that can be said is that *emergences* are completely prevented at the temperature used, but that the mean pupal period is only increased by an amount which at first is a good deal less than the high temperature conditioning period. The increase in the pupal period only corresponds to the successive increments in the conditioning period when the latter exceeds 3 months, a point which one therefore presumes is in excess of the quiescent period for the bulk of the pupal population. There is a further complicating factor in that prolonged exposure to an inhibiting temperature seems to accelerate subsequent development.

(vi) *The Effect of Waterlogging.*—It has previously been reported that submergence in water for periods longer than 1 week is enough to kill developing pupæ, but that with non-developing pupæ the result is to retard their emergence for a length of time approximating to the submergence time. These results were obtained with naked pupæ and as the effect is of some importance in explaining the suppression of emergences at the height of the wet season, it was desired to test the effects of soil waterlogging on enclosed pupæ, at a time when emergence from these is due to start.

A population of long-term pupæ, enclosed in their earthen cells, of the correct age, was therefore subjected to waterlogging, using saturated sand, for periods of 1, 2 and 4 weeks continuously and for the same total period discontinuously, a week of waterlogging being followed by a week of dry conditions. It was found that emergence was completely prevented by waterlogging, developing pupæ being killed, and that the pupal period was increased by an amount of the same order as the submergence period, whether this was continuous or discontinuous.

Field Experimental Work.

The control of red bollworm on the Lower River by means of early cropping and early uprooting introduces a dilemma which seems at first inescapable, viz., how to achieve this object under conditions of land usage which demand intercropping and economic conditions which forbid any decrease in food production.

Two possible lines of enquiry suggest themselves: the temporal and spatial arrangement of the two crops so as to give a minimum of interference, and the early removal of the food crop from the land. Experiments on these lines are described below.

(i) *Effect of Time of Planting and Arrangement of Maize on Early Interplanted Cotton.*—The usual native practice is to plant maize during the first big rains in rows about 3 feet apart, rather widely spaced in the row, with cotton planted between the rows of maize at times varying from a few days to several months afterwards. A multiple factor experiment was carried out in 1944 on the effect of variations of this basic arrangement, the cotton being planted throughout at the usual recommended spacing of 3′×2′ in early January.

As the interest of the experiment lies in the degree of earliness which can be achieved, the results below refer to cotton harvested before the end of July. In the face of concentrated bollworm attack, which inevitably occurs on early-planted cotton with the present high bollworm potential, it is difficult for a tendency towards earliness (as measured, say, by bud formation), to express itself as actual yield. Consequently, any results which are obtained under present conditions are likely to be emphasised under the conditions of low bollworm attack which we believe early cropping would encourage. The highest yield of cotton, harvested prior to the end of July, obtained in the experiment approached 600 lb. per acre. By Lower River standards this is excellent. The following conclusions were reached :—

(*a*) A fortnight's difference in the date of planting of maize resulted in an increase of 81% in the yield of cotton, the maize planted 5 weeks earlier than the cotton being superior to that planted 3 weeks earlier than the cotton. The yield of the earlier-planted maize was itself superior.

(*b*) The yield of cotton from widely spaced rows of maize (6′) was 75% higher than from closely spaced (3′) rows of maize. On the other hand, the yield of maize dropped by 36%.

(*c*) There was no difference in the yields of cotton from maize spaced at 2′, 3′ or 4′ in the row, but maize spaced at 5′ in the row gave an increase of 24% in cotton yields over the closer spacings. On the other hand, the maize yield dropped by 17%.

(*d*) There is a suggestion of an interaction (not, however, significant) between time of maize planting and inter-row spacing, in the sense that late planting of maize is less deleterious at the wider spacings.

The results of the experiment are encouraging, since they show that very considerable increases in earliness of cotton—and of absolute yield even under present bollworm conditions—can be attained by suitable manipulation of the arrangement and planting date of intercropped maize, at a price, in terms of diminished maize yield, which is not unreasonable. Moreover, the results suggest that provided the spacing *between* the maize rows is wide, that *within* the rows can be closed up with little, if any, detriment to the cotton but with some gain to the maize yield. What would be equivalent to drilled rows of maize, 6′ apart with only 6″–12″ between the plants, might, therefore, give the necessary earliness in the cotton, whilst only reducing maize yields to a negligible extent.

(ii) *Effect on Earliness of Cotton of Different Methods of Harvesting of Maize.*—The usual native practice is to leave the cobs on the maize plants until they are dead ripe and then to harvest them and uproot the haulms in one operation. The maize thus remains on the field, shading the interplanted cotton, for some time after it is ripe. Work at Barberton some years ago (Rose, M. F. (1939)—*Repts. from E.C.G.C. Expt. Stns.*, 1937–38), has shown that stooking of maize can be done without loss of yield or quality of crop at least a fortnight before the crop would normally be judged to be ripe for harvesting, the cob continuing to draw nourishment from the haulms whilst in the stook. Substantially the same results have since then been reported from the U.S.A. (Aldrich, S. R. (1943)—*Journ. Amer. Soc. Agronomy*, 35, 667). Clearly such " premature " harvesting might be of the greatest value in increasing earliness in interplanted cotton.

An experiment was therefore carried out in 1944, in which the effect on earliness and yield of interplanted cotton, as measured by seed cotton harvested by the end of July, was determined in the following treatments :—

(*a*) *Control.*—Cobs harvested and haulms uprooted at 128 days from planting, when judged ripe.

(*b*) *Stooked Early.*—Whole plants stooked at 106 days.

(*c*) *Stooked Late.*—Whole plants stooked at 114 days.

(*d*) *Layered.*—Haulms bent over 1′ above ground at 114 days ; plants laid flat but not resting on ground.

In all treatments the maize was planted at 3′×4′ and the cotton at 3′×2′. Cobs from all treatments weighed at same time, when dry.

There was no difference in yield of cobs between any of the treatments, the early stooking actually gave the highest yield (3,820 lb. maize on the cob per acre). Unfortunately the cobs were accidentally mixed after weighing and the shelling out turn for the treatments separately could not be determined. The yield of cotton up to the end of July was low for all treatments on the particular field used, but even so, early stooking gave an increase in yield over the normal African method of harvesting of over 60%. This line of enquiry is evidently worth pursuing further.

(iii) *Effect of Dry Season Cultivation and Mulching on Pupal Carry-over.*—Experiments at the Cotton Station, Domira Bay, previously reported, have shown that digging cotton fields immediately after uprooting, in July, results in a considerable reduction in the carry-over of live pupæ to the following season. These results have again been confirmed, though less strikingly than before.

It was suggested in last year's report that the inhibition of long-term pupal development in the hot dry season, which postpones the emergence of May–June formed pupæ until the new season's crop is available as food, might be prevented by mulching. The small-scale

experiment on this point in 1943 showed that a heavy mulch (actually heavier than would be practicable) could reduce soil temperatures to well below the critical point, but it also had the unexpected effect that predator activity was also greatly increased, the two effects combined producing a large diminution in carry-over.

In 1944 an experiment was carried out on a larger scale, including the effects of early digging, moderate mulching, and the encouragement of weed growth in the later stages of the cotton crop. The results confirmed those of 1943, the weedy plots in this case being the most successful, with a population of live pupæ at the end of the dry season little more than one-third of that on plots treated in the usual native style, *i.e.*, clean clearing and burning of all plant residues after uprooting the cotton. It seems, in fact, that any sort of cover to the soil in the hot dry season would be beneficial. From the point of view of wind and rain erosion, such a protection is also, of course, highly desirable.

PROGRAMME FOR 1944-45.

After the report which is at present being written has been presented, further work will be confined to a minimum of routine recording, designed to keep a check on the influence of control measures on bollworm activity and crop behaviour, and field work on the agricultural problems raised by the application of these measures. This work will be started by Mr. Pearson and arrangements will be made for it to be completed after his departure.

1. Skeleton work on insect pest populations and crop development and loss at three of the original recording sites in the Lower River.
2. Conclusion of field pupation records on long-term pupæ from 1944 season.
3. Further combined time-of-planting and spacing experiments with maize and cotton in relation to early cotton crop production and efficient land utilisation.
4. Further experiments on the effect of early harvesting of maize by stooking, layering and stripping in relation to early cotton crop production.

PROGRESS REPORT.

Part II.

There are no detailed experimental results to be recorded in Part II of the Report.

[*Included by courtesy of the Nigerian Government.*]

NIGERIA.

PROGRESS REPORT ON COTTON GROWING IN THE NORTHERN PROVINCES FOR THE SEASON 1943-44

BY

W. E. BOND.

INTRODUCTORY STATEMENT.

Inherent Agricultural Circumstances.

(*a*) The main cotton-growing area of Northern Nigeria lies within the evergreen orchard bush type of vegetation in which *Isoberlinia doka* is the characteristic fire-resistant woody species. Tall grasses, of which *Hyparrhenia rufa* and *Andropogon Gayanus* are the commonest, form the dominant ground flora and result in fierce bush fires during the dry season.

(*b*) Most of the soils in the cotton belt are derived from igneous formations chiefly granitic gneisses with addition of drift from the north which, according to Doyne, Hartley and Watson (1) is responsible for the high proportion of fine sand which causes these soils to become easily waterlogged in the rains and makes them so hard as to be unworkable in the dry season. Lateritic concretions occur at varying depths below the surface, and where erosion has taken place, as on the crests and upper slopes of hills, the laterite is near the surface and the soil tends to be red in colour. In depressions and on the lower slopes of hills where deposition has occurred, the soils tend to be yellow-grey. These yellow-grey soils are more suitable for cotton than the red soils, but owing to the high content of fine sand and increasing amounts of silt and clay with depth, they become waterlogged where surface run-off is limited, and *per contra* erode badly where the slope is steep. Moisture is, however, retained in the lower strata of the soil throughout the dry season and this enables the natural grass and evergreen vegetation to put out abundant new growth in January, February and March after fire, although the last rain of any consequence usually falls at the latest early in October. The following analysis of a typical cotton soil is taken from the same paper (1) :—

Analysis of Fine Earth from Cultivated Land Shika, Zaria Province.

Depth.	*Coarse Sand.*	*Fine Sand.*	*Silt and Clay.*	*pH*		*Exchangeable Bases.*		
				Normal.	*Exchange.*	*Present.*	*Absorbed.*	*% Saturation*
0–4″	11·8	67·9	20·3	5·3	5·0	3·26	1·80	64·0
4–12″	6·8	57·2	42·0	5·1	4·6	4·30	2·80	61·0

The base status of the soil is very often higher at the surface than in the horizon immediately below it. In many instances, particularly

with immature soils derived from igneous rocks, there is a continuous increase of acidity with depth. These soils are undoubtedly well suited to cotton.

(c) Erosion is prevalent and the planting of cotton on ridges with furrows between, which may run in any direction with regard to the slope of the land, cannot be said to discourage erosion. Yet it is recognised by the natives that cotton has a beneficial effect on the soil as new land or land that has been left fallow for a number of years is broken in by first planting cotton. According to Doyne, Hartley and Watson (1) "It is probable, however, that the greatest losses in fertility are due to erosion rather than leaching." The rainfall of the cotton belt varies from 30 inches to 50 inches per annum, falling mostly between May and September, although in the more southerly areas with heavier rainfall, rains in April and October are frequent. Cotton is usually planted after millet, guinea corn and groundnuts, in that order, have been planted, and does not usually go into the ground before July. Drought during the vegetative period does not therefore usually affect cotton, but the amount of rain that falls in September and October influences the yield to a very great extent. The longer the rains continue, the more the later bolls are able to develop and the smaller the amount of shedding. Exceptional rains late in October or early in November are liable to produce a high proportion of stained lint. The average rainfall figures for Zaria for 27 years (1904–1931) are as follows :—

Month.	*Average Rainfall.*
January	·002 inches.
February	·018 ,,
March	·31 ,,
April	1·75 ,,
May	4·61 ,,
June	6·46 ,,
July	9·25 ,,
August	12·35 ,,
September	8·48 ,,
October	1·48 ,,
November	·024 ,,
December	·05 ,,
	44·78 inches.

Very soon after the rains cease in October, or even in September, the humidity of the air falls rapidly owing to the harmattan, a very dry wind which blows throughout the dry season from the centre of the continent, coming mostly from the East and North-east. Relative humidities as low as 2% (4) have been recorded. This rapid onset of extremely dry conditions limits boll formation and is almost certainly one of the factors responsible for the high proportion of immature hairs and resultant neppiness of the yarn spun from certain samples in certain years.

In the more northerly areas of the cotton belt rainfall is from 30 to 35 inches per annum and the soils are lighter, containing a higher percentage of coarse sand. The vegetation is mixed evergreen and deciduous, but deciduous combretaceous species and rather shorter grasses predominate. Waterlogging is less frequent and drainage is better and the soils have on the whole a higher nutrient status,

possibly because erosion is less pronounced. In this area yields of cotton are limited chiefly by the amount and duration of the rains.

Native Agricultural System.

(*a*) As previously stated, cotton is frequently sown on new land or land that has been left fallow for some years. Cotton is sown after the grain crops and groundnuts have been established. The length of the bush fallow depends on the amount of land available, but with the increase in population and cultivation in the cotton belt it is becoming shorter and shorter and has disappeared altogether in parts of Katsina Province.

(*b*) No strict rotation is followed, but where the bush fallow is possible it is of this nature :—

Bush fallow (say, 5 years).

Cotton.

Guinea corn (or Millet and Guinea corn) repeated for 2 or 3 years.

Bush fallow.

Manure is not applied to cotton on new land, except where the land has been the site of a cattle kraal. Manure in the form of ashes, household refuse, dung of donkeys, horses and goats, is applied direct to millet and guinea corn. Land on which guinea corn has been grown is also manured by kraaling. The nomadic cattle owners are paid in kind (corn and fodder) for allowing their cattle to be kraaled on farm land in the dry season.

(*c*) Cotton does not appear to compete to any extent for land otherwise available for staple food crops, but cotton and groundnuts are interchangeable to a considerable extent, especially in the more northerly areas of the cotton belt. Frequently poor early rains or lack of groundnut seed results in a sudden demand for cotton seed for planting instead of groundnuts at the end of June or in July. Apart from this factor it does not appear that the area under cotton could be greatly increased without radically changing the system of native agriculture.

(*d*) With hand cultivation alone the labour available after the food crops have been weeded limits the area of cotton that can be grown in all but a few very densely populated areas. Cotton picking is done mostly by women and children at a time of the year when there is little else to do. To pick cotton by paid labour would be hopelessly uneconomic.

(*e*) As cotton seed is distributed free by the Native Administrations to dumps conveniently situated in the growing areas, the farmer has only to meet the small expense of fetching the seed. But it is believed that agents of buying firms issue a considerable amount of credit to farmers against standing crops of cotton.

Agricultural Practices.

(*a*) Average yields of cotton on peasant farms are usually taken as being from 150 to 200 lb. seed cotton per acre. Average yields on the departmental farms are higher as they do not include low yields such as are obtained from outlying peasants' farms which receive scant attention during the growing season once the seed has been planted, or which have been planted very late.

Average yields Kano Expt. Farm, 1925–1936, 260 lb. seed cotton per acre. (2)

Average yields Samaru Expt. Farm, 1924–1936, 240 lb. seed cotton per acre. (3)

(*b*) There are great possibilities in the use of cattle-drawn ploughs in cotton-growing, and the D.Y. and Emcot ploughs have amply proved their worth in the hands of mixed farmers for breaking new land after stumping, ridging land before planting cotton, and ridging up cotton during the growing period. Nevertheless, even with cattle-drawn implements, a considerable amount of hand weeding must be done if high yields are to be obtained.

(*c*) Cotton occupies no fixed place in a rotation, but it is the commonest crop with which fallow land is broken. Otherwise cotton is sown in or after millet and is frequently itself interplanted with cowpeas. Experiments so far have shown that if the millet is widely spaced as is frequently the case in native practice, yields of cotton are not reduced to any appreciable degree.

(*d*) In the main belt cotton is not usually manured, nevertheless cotton is a good indicator of soil fertility and will scarcely grow in impoverished land. North of the main cotton belt on sandy soils and with a lower rainfall, it will only grow on well-manured land inside or just outside the towns and villages or in low-lying situations where there is an accumulation of rich top soil.

(*e*) Cotton is sown from the end of June onwards and experiments carried out at Kano (2) and Samaru (Zaria) (3) have shown that the earlier plantings give the greatest yields. But on heavy waterlogged soils, if planted too early, cotton is liable to suffer from Blackarm. But as already explained, there is little danger of this in the native practice since farmers are usually too busy planting and weeding food crops to plant cotton too early.

(*f*) The ridges are usually 2 feet 6 inches to 3 feet wide and the stands are from 1 foot to 3 feet apart. Experiments indicate that the optimum spacing lies between 1 foot and 2 feet. As seed is issued free, farmers use it extravagantly and it is common to see as many as 15 plants growing in one stand. Vigorous propaganda is being carried out to persuade farmers to thin to two plants per stand and this has met with considerable success in the main centres of production.

(*g*) Cultivations vary in number, but consist of one or two weedings with one earthing-up during the early stages of growth followed by another shortly before the onset of the dry season. A further cultivation to destroy weeds is frequently given after the last rain has fallen.

(*h*) No seed bed preparation as such is given. The land is put up into high ridges, sometimes roughly weeded and then planted.

The Position of Cotton as an Economic Crop.

The price offered for seed cotton in the local markets is always higher than the export price, especially in areas some considerable distance by road from the railhead where the export price is consequently several tenths of a penny below the railhead price, the farmer does not find it worth his while to grow a surplus for export over and above the requirements of the local markets where it is on sale all the year round for spinning and weaving into native cloth. In the more northerly parts of the cotton belt, groundnuts and cotton compete for the export market to a certain extent but are also complementary in that cotton can be planted much later than groundnuts.

Cotton Varieties.

(*a*) Allen Upland American, originally obtained from Uganda in 1912, was selected and multiplied and first issued to farmers in 1921. During the course of multiplication it has almost certainly become crossed to a certain extent with native varieties as is shown by the great variation in fuzz characters of the commercial seed now grown. No other introduced variety has so far compared favourably with Allen either for yield or strength or disease resistance. Allen is now virtually the only cotton grown in the Northern Provinces with the exception of Ishan cotton, which grows in the valleys of the Niger and Benue in an area called the Middle Belt of Nigeria. Here the crops and systems of agriculture are more akin to the Southern Provinces than the Northern Provinces, and agricultural work in these areas is supervised from the Department in Ibadan.

(*b*) Yields of Allen on native farms are low, as already mentioned, largely because the peasant farmer cannot plant cotton early as food crops must be established first. The first requirement for any strain or variety to replace Allen is therefore that it should develop quickly and set many bolls in the 16 weeks between planting in July and the onset of very low humidity (with high temperatures) in early November. So far no introduced variety has been able to compete with Allen in this respect ; but several selections from within the Nigerian Allen have proved to be consistently high yielders. Other requirements are increased resistance to the pests and diseases mentioned in the next section.

(*c*) The chief faults of Nigerian Allen from the spinners' and manufacturers' point of view appear to be neppiness and weakness which are due to a relatively high proportion of thin-walled and dead

hairs. An experiment in 1931 confirmed the general conclusion that, other things being equal, cotton grown on good or well-manured land yields a lower proportion of dead hairs than that grown on poor land. A large proportion of the Nigerian Allen crop is grown on unmanured land which is often insufficiently weeded. It is thought that the immature seeds and immature hairs are due to the sudden change from relatively humid conditions in early October to very arid conditions in November, which results in acute competition between the seeds within the boll for available plant food. However, an investigation in 1927 ([4]) did not show any appreciable change in immaturity between pickings on 26th November, 14th December, 29th December, and bulked pickings on 4th, 8th and 11th January. Watering on alternate days commencing 5th November (when the first boll opened) resulted in more normal hairs than the controls at all pickings, but no consistent reduction in the number of dead hairs. If the cause of immaturity is climatic it would appear to operate before the first boll opens, *i.e.*, in October. No introduced variety has yet been found superior to the local Allen in both quality and yield. H 21, imported from America in 1927, was reported on by brokers in 1929–30 and 1930–31 to be strong and free from nep, but yields in 1929–30, 1930–31, and 1932–33, were disappointingly low compared with standard Allen. H 21 was used in hybridization, but all crosses failed. Single-plant selection from within the standard Allen has not resulted in any increase in strength, with the probable exception of 26C.

Pests and Diseases.

(*a*) *Blackarm*—does not normally reduce yields of Allen to any extent.

(*b*) *Jassids* (*Empoasca* sp.)—the most serious pest in Northern Nigeria. Introduced varieties, *e.g.*, Acala ex U.S.A., have succumbed or shown themselves to be very susceptible to jassids. Hairiness is correlated with resistance to jassids and E 31, a selection from Allen, is very hairy and immune to this pest. It has a number of dead seeds per boll and is itself useless, but is being kept for possible use in hybridization. ([5])

(*c*) *Leaf Curl* (produced by white fly *Bemisia* sp.). Native cotton from Sokoto (*G. peruvianum*) is markedly resistant, while an otherwise promising Uganda strain, S.G.27, had to be discarded because of susceptibility to leaf curl and Blackarm.

(*d*) *Stainers* (*Dysdercus* spp.). Early-planted crops are most liable to attack and native cotton (*G. peruvianum*) is very susceptible.

(*e*) *Bollworms* (*Diparopsis* sp., *Argyroploce* sp. and *Earias* sp.) do a certain amount of damage.

(*f*) *Leaf-rolling caterpillars* occur but do very little damage.

Seed Supply.

Grade I seed is distributed from ginneries to dumps in the growing areas. The various Native Administrations meet the whole cost so that farmers have to make only a short journey to collect seed.

Marketing.

Seed cotton for export may only be bought in gazetted areas and markets by licensed buyers, and all seed cotton is graded by examiners before it is bought in the markets.

Uses of Cotton Seed.

Cotton seed is not processed for oil. It is used as fuel for running gas engines by which the ginneries are operated. Cotton seed tar is a useful by-product. Excess cotton seed is used for feeding Government cattle on our stock farms, and to a certain extent by peasant farmers, but in this case only from the seed cotton which is de-linted by women for the local weaving industry.

Conclusions Drawn from Work in 1943–44.

1. No selection work or yield trials were carried out owing to shortage of staff and pressure of war work. Promising selections from Nigerian Allen made prior to the war were maintained in progeny rows and others from N'Kourala from the French Sudan, Oases from Geidam, and natural hybrids of Allen with *G. punctatum* ex Kontagora. Mass selection of commercial Allen, started in 1940, was continued.

2. Selected derivatives from D5, D8 and D30, high-yielding strains of Nigerian Allen, were multiplied and sent to Daudawa for further multiplication.

3. Sample bales of 26C (derivative of D5) and commercial Allen grown in adjacent plots in 1942–43 were sent to England, and both the Shirley Institute and the brokers reported that 26C was as strong as commercial Allen, that the yarn was superior and that it was valued more highly. This, taken together with favourable reports on 26C in 1939–40 and 1940–41, indicates that we have at last found a strain that combines quality with yield. 26C yielded 60%, 72% and 100% more lint per acre as compared with Standard Allen in 1939–40, 1940–41 and 1942–43 respectively.

PROGRAMME OF WORK FOR 1944-45.

1. Maintenance in progeny rows of derivatives of D5, D8 and D30 until pure line selection can be resumed.

2. Continuation of mass selection of Allen.

3. Multiplication of 26C on 4½ acres to provide seed for distribution to Daudawa in 1945.

4. Small-scale yield trial at Samaru of 26c, mass selected commercial Allen, D5, D30 and standard commercial Allen (from Funtua ginnery, *i.e.*, seed unaffected by our selection work). Object :—to test 26c once more for yield and lint characters—sample bales of each treatment to be sent to Shirley Institute for spinning tests and brokers' reports.

5. Yield trial at Daudawa of :—

(*a*) mixture supplied from Samaru for multiplication in 1944–45 ;

(*b*) seed harvested from 1943–44 Stage I multiplication ;

(*c*) seed harvested from 1943–44 Stage III multiplication ;

(*d*) ordinary Grade I seed ex Funtua ginnery ;

(*e*) ordinary Grade I seed ex Zaria ginnery.

Object : to compare mixtures of improved strains issued from Samaru in 1942, 1943 and 1944, against unselected Allen from the Funtua area and Allen from Zaria, in order to find out if the increased yields of improved mixtures are being maintained, and to see that quality is not being sacrificed to yield.

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PROGRESS REPORT ON WORK ON COTTON IN THE SOUTHERN PROVINCES FOR THE SEASON 1943-44

Part I.

Selection work on cotton for the year 1943–44 followed the programme of work submitted in last year's progress report.

Main Conclusions Drawn from the Results of Last Season's Work.—An experiment showed that the suspected loss of vigour in Ishan cotton of recent years may not be attributable to continuous self-fertilization.

Growth and yield of Ishan A selection were good.

Helopeltis attack was again severe.

Work on local rough-linted cotton has been abandoned.

PROGRAMME FOR THE SEASON 1944-45.

Establishment of 32 progeny rows, to be grown from seed of 16 selected plants from the better-yielding self-pollinated strain. Half of the plot to be grown from self-pollinated seed and the rest from open-pollination.

PROGRESS REPORT.

Part II.—Details of Experiments, 1943-44.

The cotton season commenced with drought in July until early September. Although there were over 5 inches of rainfall in the month of July, this was not well distributed—4 inches of rain fell on the night of the 1st, and the rest of the month had a total precipitation of 1·93 inches. Thereafter rainfall was very sparse until mid-September. From that time onwards there were frequent small rains which continued until November. These latter rains helped the plants in the last stage of growth.

The total rainfall during the four critical months of growth, *i.e.*, July to October, was 15·04 inches compared with 22·39 inches, the corresponding monthly average figure of the previous five years.

In recent years on Moor Plantation, Ishan cotton exhibited some signs of poor vegetative growth and decline in yield. Doubts were expressed as to whether inbreeding due to continuous self-pollination since 1924 was responsible. To test this, two bulk strains of Ishan A were selected and the open (crossed) and self-pollinated seeds from them were obtained. These two strains were tested in two 4×4 Latin Squares for comparison in growth, vigour and yield.

The vegetative growth of the plants was excellent and the yield was good.

Statistical results showed one strain yielding significantly higher than the other, but on the average, controlled pollinated (selfed) strains did not show changes of any significance over the open-pollinated (crossed) ones ; but in the poorer family the self-pollinated strain was significantly lower in yield.

The rough-linted cotton selected from native farms in the Ishan districts in January, 1941 (in an attempt to evolve a rough cotton of really satisfactory growth and yield) which has since been on trial, has proved too susceptible to insect attack, and has been found inferior to Ishan A ; it has therefore been abandoned.

As in five previous years excepting one (1940), attack by *Helopeltis* was again severe during the season. Its effect on cotton in the selection plot was, however, put under control by rigorous daily hand picking of the pest.

WEST INDIES.

THE AGRICULTURAL PROBLEMS OF THE WEST INDIAN COTTON INDUSTRY

BY

J. B. HUTCHINSON.

Sea Island cotton is the most suitable cash crop for considerable areas in the British West Indian islands. Its maintenance on a stable basis in the post-war economy is therefore of very great importance to those concerned with the welfare of the island communities as well as to those interested in assuring a steady supply of the finest cotton.

The future success of the industry depends on three basic factors—(1) the maintenance of the present high standard of uniformity in the product, (2) the control of pests and diseases, and (3) the improvement of yield to give a satisfactory return in the face of increased competition from other fine cottons.

Uniformity in the product has been achieved by very careful attention to breeding and seed supply. At present the whole crop is produced from three varieties, all of which are closely bred and genetically very uniform. The average amounts and proportions of the crop contributed by them over the seasons 1935–36 to 1939–40 are given below :—

Variety.	*Islands.*	*Lint yield, 1935–36 to 1939–40.*	
		Average (lb.).	*Per cent.*
MSI.	Leeward Islands	1,424,012	73·8
V.135	St. Vincent	499,344	25·8
BSI.	Barbados	7,458	0·4
		1,930,814	100·0

The industry is dominated by the production of M.S.I. in the Leeward Islands. Barbados production is of little account, and the Island's breeding work is—and is likely to remain—on a minimum maintenance basis.

Two other varieties may find a place in the industry. VH is a superfine selection from hybrid material from a cross between V.135 and MSI. It is a better yielder than V.135 in St. Vincent, especially on poor land. Though of slightly lower spinning value, it is likely to give a better return to most growers than V.135, and if the market is unable to absorb the St. Vincent V.135 crop at a premium sufficient to offset its lower yield, it will pay the island to revert to a two-variety system, growing VH as the main crop and confining V.135 to the lands to which it is best suited. The other variety of possible value is BD, a St. Vincent " ordinary " of rather better quality than MSI. It is

the only variety that has shown any promise against MSI. in the Leeward Islands, and would be the only possible alternative if it was found that a rather better quality was required to compete with the newer Egyptian strains.

The complete collection of Sea Island varieties now maintained in St. Vincent provides a reservoir of variability that will be the basis of any future breeding work. So far as can be seen at present, however, the varietal needs of the industry will be met by the five varieties mentioned above, and the rest of the collection should be carried on as a safeguard in case of long-term changes in demand or agricultural requirements that cannot now be foreseen.

Though some features of pest incidence on Sea Island cotton remain to be elucidated, the main problems of control have been solved. The protection of the crop from serious pest attacks now depends on the efficient carrying out of close season and clean-up regulations and prevention of the re-establishment of alternative stainer hosts, and on prompt and thorough destruction of fresh invasions of cotton worm.

In the past the greater part of the technical assistance given to the Sea Island industry has been devoted to the improvement of the varietal situation and to pest control, and it is in consequence of the success of this work that seed supply and pest control are now largely routine matters. Yield improvement by cultural methods has not received the same attention, but enough has been done to show on the one hand the crying need for better farming systems, and on the other, the great opportunities that exist for agricultural betterment.

The problem created by the pressure of the expanding population on limited land resources has been emphasised by all who have studied the social conditions of the West Indies. The possibilities of relief offered by more intensive agriculture may be illustrated by the disparity in cotton yields between estate and peasant holdings in St. Vincent. Manning (1943) reported that in 1942–43 the mean yield of lint from all estate cultivations was 142 lb. per acre, and from all peasant cultivations, 62 lb. per acre. When it is considered that yields of 400 lb. per acre by no means uncommon, the scope for improvement by better farming methods can be visualised.

The exploitation of the possibilities of improved yields by better farming depends on the extension of present knowledge of West Indian soil types, their rehabilitation where they have been eroded, their conservation and amelioration by suitable cultivation methods, and their improvement with organic and mineral manures. The soil sequences in the cotton-growing islands have been outlined by Professor Hardy, with the help of agricultural officers in the islands, and some information is available on the mineral nutrient status of the main types. Soil conservation work has made a good start, but has not yet been linked up very closely with studies of soil type and the information available on nutrient status.

The Sea Island crop is timed to mature in two different seasons. In most islands it is planted in August or September and ripens in the dry weather from January to April. The plant develops in an environment which is steadily becoming drier, and the sequence of vegetative and reproductive growth is normal. In general the cropping seems to be dominated by the nitrogen supply, and the major manurial problem is the maintenance of the optimum nitrogen level. In Montserrat and St. Kitts the crop is sown whenever suitable rains occur in the comparatively dry months of March and April. There the plant develops in an environment that gets progressively wetter, and the normal sequence of vegetative and reproductive growth is apt to be seriously upset, especially on the shoal soils with impeded drainage that comprise a large part of the cotton lands of Montserrat. Unless the fruiting phase is well established before the onset of heavy rains, the plant " runs to bush," " black boll " takes much of the crop that sets, extensive sheeding occurs, and in extreme cases physiological diseases (chibble leaf, loggerhead) set in and lead to complete sterility of the upper branches. These physiological disturbances are often more severe on lands with a high nitrogen status, and under such conditions nitrogen manuring may be no more than a gamble on the weather.

It is noteworthy that on the shoal soils of Nevis, with September planting, these physiological disturbances have not been reported. Though the obvious solution of the physiological problem would appear to be to change the planting season to September, there is no denying that, given a favourable weather sequence, Montserrat produces heavy crops, in spite of its large area of comparatively intractable shoal soil. Montserrat and St. Kitts, over a 23-year period ending 1941–42, averaged 184 and 191 lb. of lint per acre respectively, against 123 lb. per acre for Antigua, 111 lb. per acre for Nevis, and 117 lb. per acre for St. Vincent. (Data from 7th Report, W.I.S.I.C.A., 1942). Evidently an understanding of the underlying factors governing the fruiting of Sea Island cotton might lead to a very large increase in crop yield.

Besides Sea Island cotton, the West Indies also produce about 1,000 bales of perennial cotton in the Grenadines. This Marie Galante cotton might be a valuable asset if the industry were properly controlled. The establishment of a central ginnery has been agreed on, and co-operative ginning and marketing are the first essentials if a good, clean, even running cotton is to be turned out. Replacement of the existing mixture of types can only be gradual with a perennial crop. Improvement is being sought by the compulsory eradication of the coarse *G. barbadense* component of the crop. A superior Marie Galante strain (AHV) is available, and only AHV seed is issued to supply the gaps caused by natural mortality and by the uprooting of *G. barbadense* plants.

The basic problem of the Grenadines is soil erosion. In Carriacou, Evelyn (1935) recorded over 5,000 acres under cotton cultivation in

1935. In 1943 the acreage surveyed for the eradication of *G. barbadense* amounted to little more than 3,000. The reduction may be ascribed entirely to erosion, and though the figures are only approximate, they give an idea of the appalling rate at which the cultivable area is shrinking. The deterioration has persisted over a much longer period. In 1787 it was recorded (Edwards, cited Stephens, 1944) that " in seasonable years " Carriacou produced 1,000,000 lb. of lint. In the last 25 years production has never exceeded 425,000 lb., and has only three times exceeded 375,000 lb. As with other West Indian islands, soil conservation can only be achieved by the adoption of a better farming system. The essentials of such a system are improved cotton cultivation, with regular replanting, a food crop rotation, and stock keeping.

COTTON EXPERIMENT STATION, ST. VINCENT.

PROGRESS REPORT FOR THE SEASON 1943-44

AND

PROGRAMME OF EXPERIMENTS FOR THE SEASON 1944-45

BY

H. L. MANNING.

REPORT—Part I.

The general problems facing the West Indian Cotton Industry have been outlined above. The problem of greatest importance to St. Vincent is that of raising the yield level of the island, without sacrificing the superfine quality for which the V.135 variety is especially valued. The prospects of improvement by improved agricultural practices are large, especially on peasant lands where the yield is regularly less than half that on estates (in the 1943–44 season 68 lb. per acre against 177 lb. per acre). Varietal improvement is also possible since it has been shown (see previous reports) that the fruiting habit of the race of V.135 now in cultivation is such that its full yielding capacity is only realised on the most fertile lands. The progress made in the establishment of superfine strains with better agricultural characteristics —especially so when grown on the poorer lands—is reported below. Every effort is being made to breed the new stocks fully up to the V.135 quality standard, but it is generally accepted that this is the upper limit, since anything either longer or finer would be unsuitable for spinning in existing machinery.

Though there is no reason to suppose that the genetic potentialities of the VH stocks represent the utmost that can be got out of the Sea Island cottons, it is believed that in the immediate future greater returns will be obtained from efforts to improve yield by better agriculture than from further extensive breeding projects.

The Season.

The rainfall distribution during the early part of the season was entirely satisfactory. Between the period of flowering and maturity, however, drought conditions prevailed. The early expectation of good crop yields was not therefore realised. Isolated attacks by the cotton leaf worm were never of serious importance and only at the Experiment Station was the Pink bollworm infestation sufficiently high as to necessitate the early destruction of the cotton plants.

A further curtailment of the total acreage was recorded. Of the 2,473 acres grown, 1,469 were planted by peasants, whose reduction from the previous season was proportionately greater than that of the estates. The overall yield of 112 lb. per acre was somewhat better than that of the previous season.

The island's planting seed supply was grown at two localities. At one, 47 acres produced 17,600 lb. of clean lint (374 lb. per acre), and at the other, 15 acres produced approximately 5,000 (333 lb. per acre). While the resulting amount of cleaned planting seed is not great, it should be adequate to plant the estimated cotton acreage in the forthcoming season.

Experimental Programme.

The pressing need for a cotton with higher cropping capacity, under low fertility conditions, to replace the current race of V.135 has been repeatedly stressed. The disparity between acreage yield of peasants and estates becomes more apparent when it is realised that nearly two-thirds of the cotton acreage, which is usually planted by peasants, produces little more than one-third of the crop. The MSI. variety, on the other hand, yields comparatively well at low fertility levels (60 per cent. more at yield levels of the order of 100 lb. lint per acre for V.135), but the lint quality is not so good as that of the Superfine V.135. The programme to improve the agricultural qualities of V.135 was begun as early as 1930 by hybridization with MSI. During the seasons which followed the first backcross of the hybrid to MSI., steady progress has been recorded both in yield, and, of equal importance, quality of these hybrids, which are now known as VH. It is satisfactory to be able to state that the quality of some of these VH strains is now within the range of variation of V.135. This has been made possible by the most helpful co-operation of the Shirley Institute. It can also be claimed that a higher-yielding strain has been bred. However, to do full justice to the problem of selection for high yield, it became desirable to examine very large numbers of progenies. This became especially necessary as the genetic variance

of the material was progressively reduced by selection of self-fertilised plants. The introduction of the replicated progeny row technique followed by balanced incomplete block designs, and, during the past season, a lattice square, has made possible the critical analysis of yield with relatively high precision. The success of the breeding programme can be gauged by the ease with which remaining genetic variability, and therefore future breeding possibilities, as estimated by the intra-group variance in the analysis of variance, can be detected. In all instances, except the comparatively unimportant bolls per plant yield attribute of VH.10, this intra-group variance is shown to be highly significantly greater than error, and the capacity for further improvement on lines later outlined, is therefore not yet exhausted.

While the importance of the analysis of yield has been realised and studied for some time, the synthesis of yield under varied environmental conditions, such as can be simulated in a factorial design, has until quite recently presented some difficulty. The varied effect of fertiliser treatment on different Sea Island varieties was recorded in 1936–37 (see Progress Report). To investigate more fully this differential varietal response to fertiliser, a 3×2^3 factorial experiment was laid out during the season under review. While differences were small it was shown that the Montserrat varietal response to nitrogen differed from that of either V.135 or VH.8. Similarly, the response of VH.8 to phosphate, though considerably less than that to nitrogen, differed from those of MSI. or V.135. The effect of potash on bolls per plant of V.135 was distinct from its effect on VH.8 or MSI.

Modern statistical technique having facilitated the confident detection of small but important differences between the more variable components of yield, an experiment to determine the effects of different times of application of nitrogen on V.135 was carried out. It was hoped that data from this experiment would have an immediate practical value in regard to the most satisfactory fertiliser application for the most important yield attribute (bolling), but owing probably to unfortunate rainfall conditions, no significant differences in yield were observed. However, the trend towards increased values for seeds per boll and lint per seed produced by late applications, suggests that in varieties where these yield attributes are more important, an experiment of similar design might provide information of some value.

It has been observed for some time in progeny row trials that self-fertilization has an important effect on the yield of certain varieties. Thus while the yield of self-fertilized V.135 hardly differs from that of " unselfed " plants, selfing causes a considerable reduction in the yield of the Sea Island White variety. In the experiment designed to provide some data on this problem, no marked differences in varietal behaviour were observed except for the Sea Island White variety. There was, however, for all varieties a lower yield from " selfed " than from " unselfed " cotton and this was accentuated in lint yield by a consistent reduction in ginning outturn.

During the season the maintenance of the complete Sea Island variety Type collection was carried on, both in progeny rows and in variable bulk plots. In addition, the provision of Superfine V.135 pedigree seed for the island's seed supply, was an important function of the Cotton Station.

PROGRAMME FOR THE SEASON 1944-45.

1. *V.135. Breeding.*—Non-replicated progenies to be grown to provide uniform pedigree seed.

2. *Breeding Trial.*—25-progeny lattice square to include selections based on Small-scale Spinning Test results and yield analyses of VH.8 and VH.10. Other selections to be included are RVH, BSI. and one V.135 as a yield standard.

3. *Small Bulks Trial.*—A serial experiment at different localities of the more important VH selections against V.135.

4. *Manurial-cum-Variety Trial.*—A factorial experiment to provide more information on the yield syntheses of the three varieties VH.8, V.135 and BSI., at different times of application of nitrogen and phosphate.

5. *Maintenance of Type Collection.*—This will be reduced to an essential minimum since the Station site is to be changed.

REPORT—Part II.

Genetics and Breeding.

While the Uniformity Trial of the season 1940–41 did not show any well-marked soil heterogeneity, it was considered that some gains in efficiency could be expected from the adoption, for the Main Breeding Trial, of balanced incomplete block designs, and more particularly, a lattice square. In the past season an 81-progeny lattice square with 5 replications was laid out. This included 15 progenies each of the genotypes VH.8, VH.9–5, VH.9–11 and VH.10; 13 inter-strain hybrids of these; some Red Sea Island × VH material, and the standards Barbados Sea Island, Montserrat Sea Island and Superfine V.46.* Two-row plots containing 8 plants were arranged in square replications. The efficiency gains over equivalent randomized complete blocks were, when intra-row and column information was recovered, very satisfactory. A summary of the analyses of variance of the more important attributes of yield, analysed as lattice squares and randomized complete blocks is shown in Table I.

* The race of V.135 now in commercial cultivation.

TABLE I.

YIELD AND YIELD ATTRIBUTE DATA FROM AN 81-PROGENY LATTICE SQUARE.

SEA ISLAND COTTON, 1943–44.

ANALYSIS OF VARIANCE.

Source of Variation.	*Degrees of Freedom.*	*Mean Squares.*			
		Bolls per Plant.	*Seeds per Boll.*	*Lint per Seed.*	*Lint per Plant.*
Between Progenies within Genotypes VH.8	14	148·75**	3·40	31·87**	76·35
Between Progenies within Genotypes VH.9–5	14	73·17	3·12	12·87**	64·15
Between Progenies within Genotypes VH.9–11	14	67·17	1·83	10·07	47·17
Between Progenies within Genotypes VH.10	14	40·79	5·74**	58·62**	67·67
Error (intra-class)	240	45·31	1·52	4·43	30·81
Effective error	—	53·9	1·63	5·02	36·69
Efficiency	—	1·51	1·03	1·14	1·70
C.V.	—	23%	8%	4%	23%

It will be seen that for bolls per plant, seeds per boll and lint per seed, the gains in efficiency were respectively 51, 3 and 14 per cent. over equivalent randomized complete blocks. For lint yield the comparable gain was 68 per cent.

Reference to Table I shows that differences between groups were highly significant for all characters. For the attributes bolls per plant and lint yield, these differences were due mainly to the comparison VH.8 against the rest. In the bolls per plant comparison, VH.10 was also significantly lower than the remainder. For yield this latter difference was partially offset by the significantly higher lint per seed.

Comparisons against the parental standards, V.46 and MSI., showed that V.46 had significantly more bolls per plant than all VH progenies except some within the VH.8 group. At the same time, 35 of these 60 VH progenies had significantly more bolls per plant than MSI. For the seeds per boll attribute, only four progenies, 2 each of VH.8 and VH.10, had significantly more than V.46, while only one in VH.10 had significantly more than MSI. For lint per seed, all VH hybrids were highly significantly superior to V.46. For lint yield 28 VH hybrids significantly outyielded V.46, and 15 their MSI. parent. Of the remainder, 2 inter-hybrid crosses, an RSI × VH, and BSI., also significantly outyielded V.46.

It is of interest to note that after 13 years of self-fertilisation and progeny row selection, the variability within and between groups is great enough to be detected with confidence. However it must be realised that only the high precision of these designs has made this possible, for with randomized complete block designs in past seasons, with fewer progenies grown, the error estimate was too large to detect yield differences of less than 30 per cent. With the satisfactory results from balanced incomplete blocks in the two previous seasons, the adoption of these quasi-factorial designs for progeny row trials has therefore abundantly justified the increased statistical computations. Again, the examination of large numbers of progenies is always desirable so long as the precision of comparisons, normally subject to wide environmental fluctuation, can be kept satisfactorily high. The lattice square here reported has made possible the confident

detection of comparatively small yield differences (20 per cent.) which would otherwise in such a large trial, be undetectable owing to a high error. A further advantage gained from this design was the provision of unbiased adjusted data for use in the multiple regression form of yield analysis.

The Small Bulks Trial, in substantiation of the Breeding Trial results, was grown at two localities and provided yield comparisons under estate conditions for the best 1942–43 selections of VH.8, VH.9–5, VH.9–11 and VH.10 against V.46. The Breeding Trial results were essentially confirmed in spite of a significant interaction between variety and locality due to a depressed yield of VH.8 at one of the localities. This was not sufficient to reduce the mean yield which, like that of the other VH's, was significantly greater than V.46. In the comparison, VH's against V.46, the yield increment was more than 13 per cent. (significant difference 10 per cent.).

Actual selections for the coming season were based on the multiple regression data provided by adjusted figures from the lattice square lay-out. Preliminary regression equations from the seasons 1941–42 and 1942–43, indicated that the relative importance of the fundamental yield attributes differed in different genotypes. The precision of this form of yield analysis is, of course, largely dependent on the reduction of non-heritable variation by use of adjusted data, but unfortunately, owing to the small size of the previous experiments, it was not possible to evaluate specific regression formulæ for the individual genotypes. In the lattice square design, however, an adequate number of progenies for each VH genotype has now made this possible. Yield analysis differed mainly between VH.8 and VH.10. In the former the independent regression on yield of bolls per plant, (β_y1.23) is by far the most important single yield attribute. In VH.10, however, while the bolls per plant attribute is, as expected with Sea Island cottons, of considerable importance, (β_y3.12), the independent regression of lint per seed on yield, is also of considerable importance. Since VH.9–5 and VH.9–11 did not differ materially from VH.8, they are not included in the diagrammatic form of yield analysis shown in Figure I for VH.8 and VH.10.

Statistical evidence is now available to show that distinctive genotypes have been isolated. This indicates also the direction in which selection pressure is most likely to result in selection advance. Thus, in VH.8, in which bolls per plant is shown to be of great importance, and where the intra-group variance as shown in the analysis of variance, is larger than for the other VH's, the main selection pressure should be exerted in favour of this character. For VH.10 it is probable that selection advances can be made by similar pressure in favour of lint per seed, for which also the intra-group variance is highest, though the important bolls per plant attribute cannot be ignored.

In summarizing the achievements of the VH breeding programme over the past six seasons, it is now quite evident that with regard to

FIGURE 1

YIELD ANALYSIS OF SUPERFINE V46 x MONTSERRAT SEA ISLAND HYBRIDS. BREEDING TRIAL 1943-44.

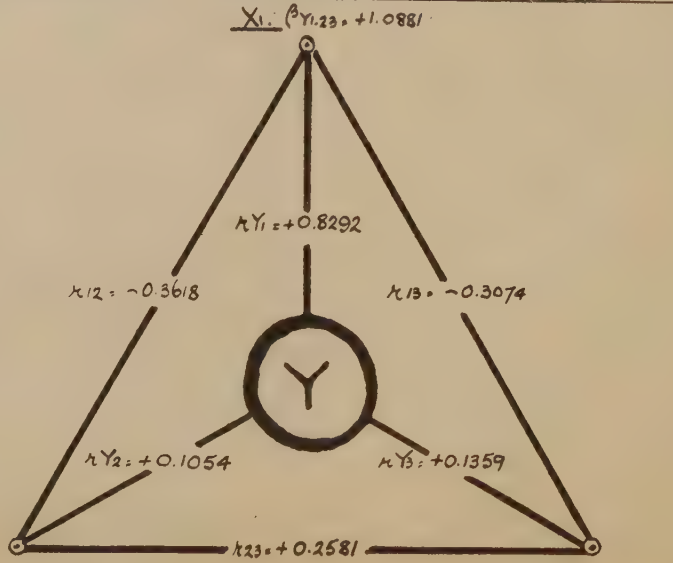
DATA FROM ADJUSTED YIELD AND YIELD ATTRIBUTES OF 81 PROGENY LATTICE SQUARE.

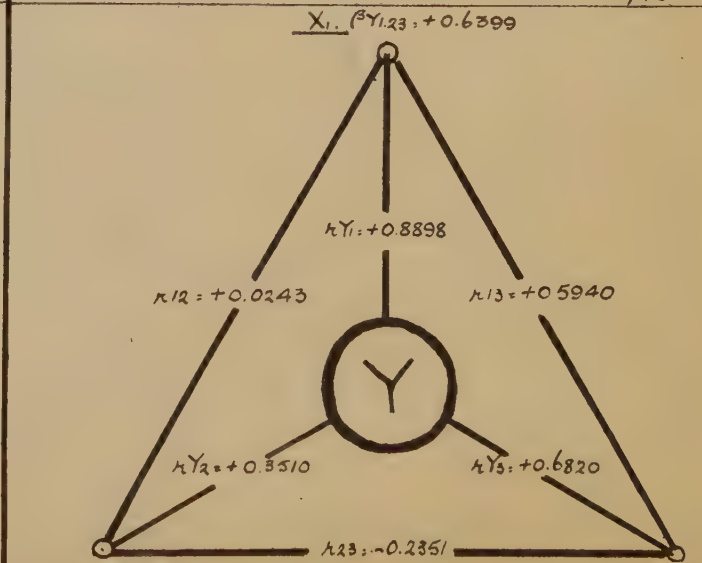
GENOTYPE VH8. 15 PROGENIES. LINT YIELD Y = 29.4 GRMS/PLANT

	X_1 = BOLLS/PLANT	X_2 = SEEDS/BOLL	X_3 = LINT/SEED
	36.4	15.5	52.2 MGM.
C.V.	15.0 %	5.4 %	5.0 %
	r_{Y_1} = +0.8292	r_{Y_2} = +0.1054	r_{Y_3} = +0.1359
	$\beta_{Y_1.23}$ = +1.0881	$\beta_{Y_2.13}$ = +0.4046	$\beta_{Y_3.12}$ = +0.3659
R^2	= 0.9023	+ 0.0426	+ 0.0497

GENOTYPE VH10. 15 PROGENIES. LINT YIELD Y = 24.7 GRMS/PLANT

	X_1 = BOLLS/PLANT	X_2 = SEEDS/BOLL	X_3 = LINT/SEED.
	27.6	15.4	57.9 MGM.
C.V.	10.3	6.9	5.9
	r_{Y_1} = +0.8898	r_{Y_2} = +0.3510	r_{Y_3} = +0.6820
	$\beta_{Y_1.23}$ = +0.6399	$\beta_{Y_2.13}$ = +0.4302	$\beta_{Y_3.12}$ = +0.4031
R^2	= 0.5694	+ 0.1510	+ 0.2749





yield this material is considerably better than V.46, the genetic variability of which is now so reduced as to make selection advances unpractical. A comparison against V.46 provides a yardstick by which to measure the VH progress since 1938–39. Data for the more important seed cotton and yield characters are shown in Table II, and VH yield increases over comparable V.46 are expressed as percentages to provide an index of the improvements accomplished.

TABLE II.

PROGRESS OF VH HYBRID MATERIAL FROM 1930–1944.

Season.	*Family.*	*Lint Length. mms.*	*Seed Weight. mgms.*	*Bolls per Plant.*	*Seeds per Boll.*	*Lint per Seed. mgm.*	*G.O. per cent.*	*VH Lint per acre.*	*V46 Lint per acre.*	*VH per cent. Increase.*	*Remarks.*
1930–31	V(30)46 ...	59	120	*	18·3	42	26·0	Not Available			Figures Based on Boll Samples
	H(39)=M.S.I.	51	114	*	22·8	60	34·0				
1931–32	F_1–VH ...	55·8	144	*	15·2	52	26·6				
1932–33	1st B/C VH × H	52·9	119	*	22·7	52	30·3				
1933–34	VH × H–11 ...	55·7	124	*	19·8	57	31·4				
1934–35	VH(34) Series...	58·3	126	*	18·7	55	30·4				
1935–36	VH(35) Series...	57·1	124·3	*	*	56·3	31·0				
1936–37	VH(36) Series...	58·5	122·7	*	*	51·3	30·1				
1937–38	VH(37) Series...	58·7	132·0	*	*	54·3	29·0				
	INTRODUCTION OF REPLICATED PROGENY ROW TECHNIQUE.										
1938–39	VH(38) Series...	59·6	126·3	—	—	53·0	29·4	427	413	3·4	Figures Based on Absolute Yield
1939–40	VH(39) Series...	59·2	125·0	29·0	13·0	47·2	27·3	211	194	8·8	
1940–41	VH(40) Series...	60·6	133·0	26·5	13·8	51·3	28·0	224	204	9·8	
1941–42	VH(41) Series...	59·9	145·7	47·1	12·4	60·5	29·4	396	†	—	
1942–43	VH(42) Series...	61·0	140·6	25·4	13·2	55·8	28·5	220	194	11·8	
1943–44	VH(43) Series...	58·6	138·6	31·9	15·1	55·6	28·7	326	287	13·6	

* Figures not comparable. † No V.135(V.46) in comparable trial.

There is now sufficient evidence that the long-term breeding programme begun in 1930–31, has resulted in the isolation of a superfine strain with yielding qualities superior to the St. Vincent commercial variety. In addition to this VH strain, which could be multiplied rapidly from available stocks, there remains other valuable breeding material with sufficient genetic variability to offer wide scope for improvement. Amongst these are intra-VH crosses and the RSI × VH hybrids.

AGRONOMY.

(1) *Fertiliser-cum-Variety Trial.*—That nitrogenous fertilisers provide the greatest single stimulus to growth and yield of Sea Island cotton under St. Vincent conditions is now well established. In a previous season, a striking dissimilarity between the effect of compost and nitrogen (equivalent to that in compost) on lint per seed suggested that the undoubted yield increment due to compost could not be attributed to nitrogen alone. The other important constituents of compost, phosphate and potash, have produced effects which have been neither consistent nor of great magnitude. In addition there has been evidence to show that a differential varietal response to fertiliser treatment exists. It was thought desirable therefore to investigate more fully the main fertiliser effects due to nitrogen, phosphate and potash on yield and yield attributes, before further trials with compost were carried out. A 3×2^3 design made possible the critical analysis of the three varieties, V.135, VH.8 and MSI., whose yield syntheses were suspected to be different, at two levels each of nitrogen, phosphate

and potash. The less important (for the purpose of experimental comparison) two-factor and some three-factor interactions were partially confounded with block differences. The resulting loss of precision for these comparisons did not, however, affect the precision of the important variety × main fertiliser effects.

Potash (at the rate of 150 lb. per acre of sulphate of potash) was applied within two weeks of sowing. Nitrogen (as 300 lb. per acre of nitrate of soda), and phosphate (as 300 lb. per acre of superphosphate) were applied at 37 days. Weekly growth measurements were taken from 44–114 days.

As expected, growth increments due to nitrogen exceeded those due to the other fertilisers. Main effects due to individual treatments were calculated and comparisons based on the specific "no fertiliser" level showed a highly significant differential varietal growth response to nitrogen. Thus the growth range as a percentage of "no nitrogen" was 34 (94–128) for VH.8, 31 (89–120) for V.135, and only 12 (92–104) for MSI. While the respective growth responses of the three varieties to phosphate and potash were small and inconclusive, there was some evidence that phosphate favoured growth of VH.8 at the time of budding and flowering.

The main effect of fertiliser treatment on yield and yield attributes is summarized in Table III, showing main fertiliser effects and ignoring the, for the most part, insignificant inter-fertiliser interactions.

TABLE III.

3×2^3 Fertiliser Trial, 1943–44.

Main Fertiliser Effects on Yield Attributes and Lint Yield.

Nitrogen (Ignoring Phosphate and Potash).

Variety.	Bolls per Plant.		Seeds per Boll.		Lint per Seed.		Lint Yield.	
	Nil.	*N1.*	*Nil.*	*N1.*	*Nil.*	*N1.*	*Nil.*	*N1.*
Superfine V.135 ...	30·8	44·2	14·6	14·3	40·3	41·7	18·5	27·2
VH.8 (Hybrid) ...	29·1	40·3	16·0	16·6	46·8	48·9	20·8	30·5
MSI.	23·0	27·5	15·5	16·4	61·7	63·4	21·7	26·7
Significance ...	N=***	VN=*	N.S.		N=***	VN=NS	N=***	VN=NS

Phosphate (Ignoring Nitrogen and Potash).

Variety.	Bolls per Plant.		Seeds per Boll.		Lint per Seed.		Lint Yield.	
	Nil.	*P1.*	*Nil.*	*P1.*	*Nil.*	*P1.*	*Nil.*	*P1.*
Superfine V.135 ...	38·1	36·9	13·2	15·8	41·2	40·9	22·8	22·9
VH.8 (Hybrid) ...	32·9	36·4	17·2	15·5	47·4	48·3	24·4	26·9
MSI.	24·3	26·2	17·1	14·9	62·1	63·0	23·8	24·6
Significance ...	N.S.		P=NS	VP=*	N.S.		N.S.	

Potash (Ignoring Nitrogen and Phosphate).

Variety.	Bolls per Plant.		Seeds per Boll.		Lint per Seed.		Lint Yield.	
	Nil.	*K1.*	*Nil.*	*K1.*	*Nil.*	*K1.*	*Nil.*	*K1.*
Superfine V.135 ...	35·6	39·4	14·6	14·3	41·2	40·9	21·8	23·9
VH.8 (Hybrid) ...	34·5	34·9	15·9	16·8	48·4	47·3	25·5	25·8
MSI.	25·8	24·7	15·8	16·2	63·2	61·9	24·9	23·5
Significance ...	N.S.		N.S.		K=*	VK=NS	N.S.	

P=0·05 * P=0·01 ** P=0·001 ***

Yield data are summarized according to individual treatments as follows :—

Nitrogen.—The total nitrogen effect, ignoring varieties, was, in general, a reflection of growth response, and the significance of the V × N interaction was due mainly to the smaller response of MSI. There were, however, varied effects on the yield attributes other than lint per seed, for which significant increments were recorded for all varieties. Thus, bolls per plant of V.135 responded more favourably to nitrogen than did that of the other varieties. However, unlike the higher-yielding varieties, VH.8 and MSI., a depressing effect on the seeds per boll attribute of V.135 resulted in a lint yield not commensurate with the increased bolls per plant.

Phosphate.—As expected, the magnitude of the phosphate response was smaller than that due to nitrogen. Some valuable observations were however recorded. Thus, while phosphate increased bolls per plant of VH.8 and MSI., this attribute of V.135 yield was depressed. In final yield the depressed effect on bolls per plant for V.135 was offset to a considerable extent by completely opposite effects on seeds per boll. Only VH.8 showed any appreciable yield increase due to phosphate.

Potash.—The potash effects, like those for phosphate, were small. However, there was some indication that its effect on bolls per plant was of some importance. Reference to Table III shows that the positive effect was confined almost entirely to V.135, the high bolls per plant variety. Although bolls per plant is not such an important attribute of yield in MSI., the effect on this character combined with that on lint per seed, resulted in a depressed yield in this variety. It was shown that for all varieties lint per seed was depressed by potash.

In conclusion, it is apparent that differential varietal responses to fertilisers exist. For the high-yielding MSI. variety, with a considerably smaller response to nitrogen, the utilization of available nitrogen is apparently more efficient. This would, of course, explain its known better cropping capacity under low fertility conditions, than V.135. Larger yield increases can be expected with the N × P combination, from the VH.8 variety. The different effect of potash on the three varieties would suggest that its effect is due rather to its reducing boll-shedding than by increasing the potential number of bolls of the high bolls per plant variety V.135. Further trials comparing compost against fertiliser equivalent must therefore be designed with care, bearing in mind the variety to be chosen and the detailed chemical analysis of the compost.

The varietal effect, ignoring fertiliser combinations, showed that VH.8 outyielded V.135 by more than 13 per cent. (significance 10 per cent.) and MSI. by more than 6 per cent. That VH.8 outyielded V.135 under the wide range of conditions provided by such a trial is additional proof of its greater suitability to St. Vincent conditions.

With the appropriate fertiliser combination indicated by this trial, large yield increments can be expected.

2. *The Effect of Time of Application of Nitrogen on the Yield Attributes of V.135.*—Previous experiments have shown that for optimum yield of V.135, the time of application of nitrogenous fertilisers is from 4–6 weeks. The precise effect of these nitrogen applications on yield attributes in synthesising yield was not, however, clear. A trial with 5 replications of 6 fortnightly applications of nitrate of soda was therefore carried out. Unfortunately the application at 4 weeks was followed within 24 hours by a rainfall of 5·20 inches. However, the analyses of variance for the important yield attributes bolls per plant, seeds per boll and lint per seed, were not without some interest.

In general the effect on bolls per plant showed no marked trend in either direction. It was thought that this unexpected result may have been due to the leaching effect of rainfall and also to the not inconsiderable shedding which took place during the growth period. On the seeds per boll and, to a lesser extent, lint per seed attributes, late application tended to increase their values. But since bolls per plant as the most important yield attribute of V.135, was not materially affected by time of application, the cumulative effect on yield was insignificant. It is possible, however, that with varieties in which lint per seed and seeds per boll are more important yield attributes than in V.135, a similar experiment might yield some valuable information.

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